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CHEMICAL ENGINEERING
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Editor's Page

The hydrogen economy moves ahead

Hydrogen is clearly one of the key drivers for decarbonizing industry and meeting crucial environmental objectives, as evidenced by the numerous announced projects and funding initiatives across the globe. This point was further underlined at the third annual HydrogeNext conference, part of Experience Power Week, presented by *Chemical Engineering* and *POWER* (www.hydrogenextevent.com). The event covered ongoing hydrogen projects, production technologies, operational best practices and much more.

Logistics, mobility and decarbonization

Experience Power Week keynote speaker Tim Echols, commissioner of the Georgia Public Service Commission, highlighted hydrogen as one of seven major trends in the energy world, emphasizing its importance in decarbonizing logistics and transport operations. "I really think the place to start with hydrogen fueling is in material-handling facilities. The low-hanging fruit for hydrogen use is forklifts, followed by Class 8 heavy-duty trucks," he said. When compared to electrification for heavy-duty trucking, Echols points out several benefits hydrogen offers. "Vehicle batteries add weight, and with hydrogen you can refuel quickly and easily. With battery-electric trucks, you will have to sit and wait longer for charging."

Another key point was hydrogen's decarbonization synergy with nuclear power generation. In a session focused on financial metrics of hydrogen projects, Mike Kramer, vice president of growth and finance at Constellation Energy Corp. (Baltimore, Md.; www.constellation.com) outlined the economics of integrating hydrogen and nuclear, pointing out that electrolysis can be modularly ramped onto existing nuclear assets from the pilot stage through at-scale production, which allows iterative cost reductions and quick production scaleup for new off-takers. As an example of a successful deployment of nuclear hydrogen production, he detailed the Nine Mile Point nuclear plant in Oswego, N.Y., which started up a nuclear-powered hydrogen plant in March 2023.

Stabilizing the supply chain

As with any emergent technology, the production of "green" hydrogen via electrolysis comes with some uncertainty surrounding the supply chain and delivered costs. In a session covering supply-chain considerations for electrolyzers, Anthony DeOrsey, research manager for Cleantech Group (San Francisco, Calif.; www.cleantech.com) emphasized that precious metals, such as the iridium often used in electrolyzers, are not the only bottleneck in the electrolyzer supply chain. Seemingly more abundant, the nickel used in electrolyzers must also compete with growing demand from lithium-ion battery manufacturers. Supply-chain concerns notwithstanding, he also stated that the tax credits and other incentives brought about by last year's Inflation Reduction Act (IRA) will help enable a "faster track to economies of scale for renewable hydrogen."

The U.S. moves its hydrogen economy forward

Another highlight was a panel discussion on the regional Hydrogen Hubs in the U.S. vying for federal funding under the IRA. Representatives from four hubs discussed the unique benefits and challenges in implementing an overarching hydrogen economy in each particular region. The regional variation of industries served, as well as differences in production and transport infrastructure and workforce considerations, illustrate the many avenues that the hydrogen economy may take as more production capacity comes onstream. ■

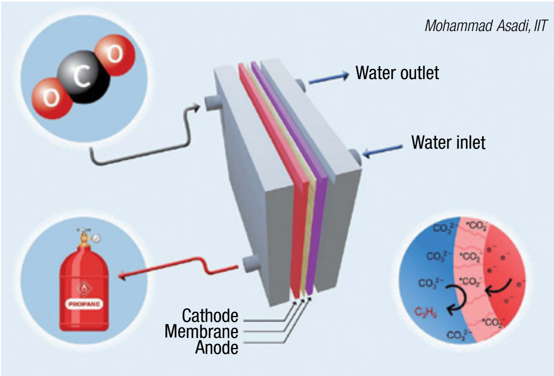
Mary Page Bailey, senior associate editor

A new electrolyzer system makes propane from CO_2

Electrolyzers are typically associated with the production of "green" hydrogen from water and renewable electricity, but a new device borrows from traditional electrolyzer principles to convert CO_2 into propane. Developed by a team of researchers from the Electrochemical Energy Materials and Devices Laboratory (e2MDLab) at Illinois Institute of Technology (IIT; Chicago; www.iit.edu) led by chemical engineering professor Mohammad Asadi, the team developed a new catalyst material to target the production of C3 products — using only CO_2, water and electricity as inputs — by optimizing the proton-electron transport reaction to ensure there was not excessive production of co-reactants and byproducts. Since the process consumes both water and CO_2, and there is competition between the two, it is crucial that more CO_2 is available in the system and less water. Excess water will lead to excess hydrogen in the system and disrupt the balance of the proton-electron coupling reaction that is required to bring together carbon and hydrogen to form propane, explains Asadi.

As reported in a recent issue of *Nature Energy*, at the heart of the electrolyzer is a catalytic system composed of a new material — 1-ethyl-3-methylimidazolium-functionalized Mo_3P nanoparticles coated with an anion-exchange ionomer. "The ionomer is a conductive polymer that suppresses the hydrogen and water in the system, which also has very good CO_2 absorption properties, to deliver the CO_2 efficiently to the catalyst's reaction region," says Asadi.

Currently, the electrolyzer has been demonstrated in a proof-of-concept laboratory model. While the current runs have used pure CO_2 streams, the team believes that the system could handle streams as dilute as 15% CO_2 due to the system's ability to readily uptake CO_2 to the catalyst region. "This is an ongoing project within the group, and we are working with funding agencies to evaluate what is the minimum range of CO_2 we can handle," adds Asadi.



Scaled up facility under construction for single-step, CO_2-to-fuels process

Construction is underway by AIR Co. (Brooklyn, N.Y.; www.aircompany.com) for a commercial demonstration plant capable of converting captured carbon dioxide into fuel-grade paraffins, as well as ethanol and methanol, in a single step. The facility will be a larger version of a pilot plant the company has been running for the past two years in Brooklyn, N.Y.

AIR's power-to-liquids technology, known as AIRMade, is intended to be a single-step alternative for utilizing waste CO_2 for production of hydrocarbon fuels and other industrial and consumer products. "Traditional chemistry for making hydrocarbons from CO_2 involves the reverse water-gas shift reaction to make carbon monoxide, followed by Fischer-Tropsch [F-T] synthesis to make hydrocarbons," explains Stafford Sheehan, co-founder and chief technology officer of AIR. "Our technology can generate hydrocarbons in the size range suitable for aviation fuels with energy costs that are half of F-T processes."

Key to the process is a proprietary catalyst that consists of a mixture of earth-abundant metals supported on alumina. The catalyst is loaded into a fixed-bed reactor into which the captured CO_2 is introduced. The company has filed for a patent on its catalyst composition and production method that mimics photosynthesis.

The reactor-catalyst system is capable of making paraffins in the range from hexane to octacosane (C28), with the majority of products in the octane to eicosane (C20) range. Jet-A fuel consists of alkanes from C8 to C18. The AIR Co. process also produces ethanol as a byproduct, from which the company has been making consumer products, including perfume and vodka.

"By converting waste CO_2 into fuels and alcohols, we are able to establish a circular process for making high-energy-density fuels for aviation and other transportation sectors that are not amenable to electrification," the company says.

Edited by:
Gerald Ondrey

CARBON CAPTURE

Membrane Technology and Research, Inc. (MTR; Newark, Calif.; www.mtrinc.com) Carbon Capture announced it has commenced construction of a large pilot plant at the Wyoming Integrated Test Center (ITC) in Gillette, Wyoming. When operational in 2024, it will be the largest membrane-based capture plant in the world.

MTR Carbon Capture will operate out of ITC's Large Test Center to collect CO_2 from fluegas produced by Basin Electric's Dry Fork Station, a coal-based power plant firing Powder River Basin coal. The Wyoming ITC is one of the world's largest post-combustion demonstration-scale test facilities.

MTR Carbon Capture will use its proprietary Polaris polymeric membrane to capture more than 150 ton/d of CO_2 at Dry Fork Station. The process uses no chemicals and requires little water, making its approach to carbon capture cleaner and more environmentally friendly than conventional solvent-based methods.

The project is part of the U.S. Department of Energy's large-scale pilot carbon-capture program.

CHEMICAL LOOPING

The world's largest chemical looping combustion (CLC) unit, constructed by a Sintef-led Chinese-European project (CHEERS), is now in its main testing phase, and results are expected in the coming weeks. As part of the project, a 3-MW_{th} CLC demonstration unit was designed and constructed in Deyang City, China. Commissioned in May, the 50-m high demonstration unit has two different configurations for different fuels: petroleum coke and lignite coal. The goal is that the unit will be able to convert a solid fuel flow of up to 4 MW_{th} into steam, while achieving a

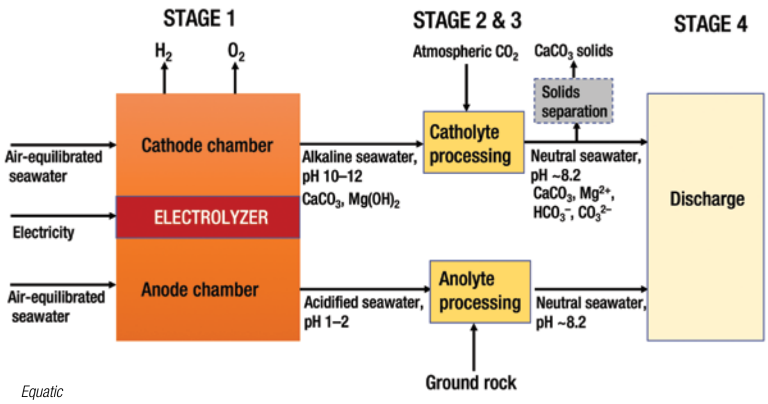
(Continues on p. 6)

Seawater electrolysis stabilizes and immobilizes atmospheric carbon dioxide

Seawater is being used in a new electrolysis scheme for carbon dioxide removal (CDR), while also producing hydrogen as a byproduct. Developed by Equatic (Los Angeles, Calif.; www.equatic.tech), the platform draws seawater into a closed electrolysis system, taking advantage of the pH difference between the produced streams for efficient capture and storage of atmospheric CO_2 (diagram). “Splitting the seawater into hydrogen and oxygen also creates two streams — one alkaline from the cathode side of the cell, and the other acidic from the anode side. The acidic seawater is neutralized with crushed minerals to restore its natural pH, and is returned to the ocean. The alkaline seawater stores carbon as a solid mineral before atmospheric air is passed through to immobilize additional CO_2 as dissolved bicarbonate ions. Finally, the sequestered CO_2 is returned to the ocean as $CaCO_3$,” explains Edward Sanders, chief operating officer of Equatic. Proprietary electrodes have been developed to prevent the production of chlorine gas species in the cell. This is a major breakthrough, says Sanders, since the presence of Cl_2 gas creates safety issues and requires treatment with granular activated carbon.

Using the ocean for CO_2 storage holds several benefits over other CDR methods, explains Sanders, including the elimination of costs associated with transport, pipeline construction and subsurface exploration. “Unlike other land-based direct-air capture technologies, this is functionally permanent CO_2 removal. There is no ocean degassing caused by atmospheric CO_2 removal. And unlike other ocean-based technologies, Equatic is able to measure, report and verify the CO_2 drawdown within the boundaries of the plant, without requiring open-ocean measurements,” adds Sanders.

The company recently published details of its comprehensive methodology for verifying its CDR performance, using an array of sensors to provide continuous process readings. Equatic currently operates two CDR plants in in Los Angeles and Singapore, each with 100 kg/d of CDR capacity. “Our next plant will be commissioned in mid-2024 with a capacity of 10 tons/d,” says Sanders.



Equatic

carbon capture rate of 96%.

CLC technology features a metal oxide that loops between an air reactor and a fuel reactor. In the air reactor, the metal oxide absorbs oxygen from the air. It then goes into the fuel reactor, where this oxygen is used as an oxidizer for the combustion process. The oxygen-depleted (or reduced) metal then returns to the air reactor to absorb more oxygen, and the process repeats. Using oxygen instead of air in the combustion process makes capturing and removing harmful particles from the resulting smoke much easier. This is because when pure O_2 is burned, the only major end products are CO_2 and water, which are then easy to separate through steam condensation. However, producing pure O_2 is often expensive. CLC technology avoids this cost, as extracting the oxygen already present in the air is an inherent part of the process.

CHEERS is an international project with nine partners from Europe and China: Sintef Energy Research (coordinator; Trond-

(Continues on p. 8)

Taking graphene into the next dimension

Graphene has been touted as a “super” material, boasting ultra-high strength, superconductivity and many more superlative properties, but, as a planar two-dimensional material, its commercial use has been limited in terms of reactivity, since reactions can only occur at the material’s edges. “With graphene, it’s not highly tunable to the exact application that you want, so you’re often designing your application around what graphene could do for it, versus designing the graphene around what’s needed for the application,” explains Keith Norman, chief sustainability officer of Lyten, Inc. (San Jose, Calif.; www.lyten.com). Lyten has developed a proprietary reactor technology to produce three-dimensional graphene (photo) at scale from a methane feedstock, creating a new class of material that is more reactive and tunable for a wider variety of applications. Norman likens the production of three-dimensional graphene to crumpling and twisting a sheet of paper. “In our reactor, bending and folding the material increases the number of reactive sites by orders of magnitude. Equally important is that we can tune the material based on how we operate the reactor. From what we’ve seen, there are no other technologies able to deliver a three-dimensional graphene material to the market. The real differentiation lies in the ability to consistently tune three-dimensional materials to exact specifications,” explains Norman.

With the unique graphene structures the technology can yield, Lyten is currently pursuing three distinct application areas: cathodes for lithium-sulfur batteries; light-weighting and reinforcement for thermoplastic composites; and advanced sensors and biosensors.

Lyten is in the process of closing its Series B fundraising round, which includes investment from leading automotive manufacturer Stellantis. Lyten currently operates an automated pilot-scale manufacturing line for graphene-enhanced Li-S battery cells in San Jose, and has commercial partnerships in place to utilize its graphene in engineered composite-based consumer products. Discussions are also underway with a major tire manufacturer to employ flexible graphene-based sensors on the interior of tires.

heim, Norway; www.sintef.no) and Sintef Industry, IFP Energies Nouvelles, Tsinghua University, TotalEnergies, Dongfang Boiler Group, Zhejiang University, Politeknika Slaska and Bellona. It is funded by the E.U.'s Horizon 2020 research and innovation program, the Chinese Ministry of Science and Technology and industry partners.

MICROWAVE SMR

In late August, Nu:ionic Technologies, Inc. (Fredericton, Canada; www.nuionic.com) entered into a memorandum- of-understanding (MoU) commercial agreement with Liberty Utilities (New Brunswick, Canada; www.libertyenergyandwater.com) for the development of a 2,400-kg/d hydrogen-production system utilizing Nu:ionic proprietary Microwave Catalytic Reformers (MCRs). This is the first commercial application of Nu:ionic's on-site, on-demand H_2-production technology, which uses microwave energy to decarbonize natural gas with electrified reforming. The proposed facility is scheduled to be in operation in the first half of 2025.

Nu:ionic's proprietary process technology will be used to generate low-carbon H_2 at low cost, for blending into Liberty's natural-gas-distribution system and clean power generation and fuel production for zero-emission fuel cell electric vehicles. The MCR design includes a carbon-capture system to produce readily transportable liquid CO_2.

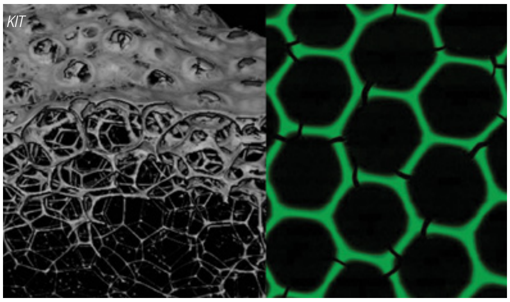
Nu:ionic's MCRs eliminate the need for fuel combustion, greatly reducing the amount of feedstock required to produce H_2 and significantly reducing greenhouse gas emissions, while also allowing for the efficient use of renewable electricity to reduce the carbon footprint of the natural gas grid. The

(Continues on p. 9)

Immobilizing enzymes as a stable, active foam

Researchers at the Karlsruhe Institute of Technology (KIT; Germany; www.kit.edu) have developed a new class of materials — enzyme foams. Normally, foaming modifies the enzyme structure and enzymes lose their biocatalytic activity. The new protein foams, however, are said to have "tremendous" stability and activity.

To produce the protein foams, two dehydrogenase enzymes are mixed, which carry matching sites to spontaneously form a stable protein network. "Then, a gas flow is added to this mix in a microfluidic chip for the controlled formation of microscopic bubbles of uniform size," explains Christof Niemeyer, professor at the KIT's Institute for Biological Interfaces 1. The foam with the uniform bubble size is applied directly onto plastic chips and dried, which causes the proteins to polymerize and form a stable hexagonal lattice (photo). "These monodisperse all-enzyme foams are three-dimensional porous networks consisting of biocatalytically active proteins exclusively," Niemeyer says. The stable hexagonal honeycomb structure of the foams has a mean pore diameter of 160 µm and a thickness of the lamellae of 8 µm.


KIT

In industrial biocatalytic processes, enzymes have to be immobilized in large quantities under the most gentle conditions in order to maintain their activity. Up to now, enzymes have been immobilized on polymers or carrier particles. However, these require valuable reactor space and enzyme activity may be reduced. "Compared to our 'all-enzyme hydrogels,' the new foam-based materials have a far larger surface area on which the desired reaction can take place," Niemeyer points out. Also, the newly developed enzyme foams are far more stable after drying for four weeks than the same enzymes without foams, he says.

The researchers used the foams to produce tagatose, which is a promising alternative to refined sugar. The achievement is described in a recent issue of *Advanced Materials*, and a patent application has been filed.

Unlocking the commercial feasibility of graphene-based water sensors

A new, non-intrusive screening method developed by researchers from the Pritzker School of Molecular Engineering (PME) at the University of Chicago (pme.uchicago.edu), as well as Argonne National Laboratory (Lemont, Ill.; www.anl.gov) and the University of Wisconsin-Milwaukee (www.uwm.edu), shows promise for scaling up commercial production of a special class of graphene-based water sensors. The sensors are tailored for the detection of lead, mercury and *E. coli* in flowing water down to the parts-per-billion (ppb) or colony-forming unit (cfu) concentration. "The graphene sensors are coated with a layer of aluminum oxide. To achieve the selectivity or specificity of the detection, we use gold nanoparticles with capturing functional groups on top of this dielectric layer," explains PME professor and Argonne's lead water strategist Junhong Chen. However, a hurdle in commercializing these types of functionalized field-effect-transistor (FET) sensors is the difficulty in quality assessment, since the sensors are just a few nanometers thick. When there is porosity present in the dielectric layer, electrical charge can accumulate, or even travel through the layer, which will compromise the sensors, and performance problems will be further exacerbated with exposure to water.

"Typically, quality control for this type of device involves measuring its electrical characteristics, such as transport curves and current-voltage [*I-V*] curves, but in many cases, this is not enough. Even if you have very uniform curves, these sensors may not necessarily demonstrate corresponding sensing performance. You need to also look into the quality of the dielectric layer to make sure we find uniform sensing responses beyond just the pure electrical transport measurements," explains Chen.

The new approach developed by Chen's team identifies high-performing devices by scanning with A.C. voltage at a wide range of frequencies to measure its impedance response. "We can find the specific threshold to differentiate good devices from bad devices by looking at the ratio of the capacitive and resistive impedance components," says Chen. Furthermore, he says, this screening method can also indicate if there is a need to tune the manufacturing recipes used for the dielectric layer deposition, giving an opportunity to potentially improve manufacturing yield.

Piloting a chemical-recycling process for polycarbonate plastics

Covestro AG (Leverkusen, Germany; www.covestro.com) has developed a chemolysis process for recycling polycarbonate back into monomers. In laboratory trials, the process has been shown to recycle waste streams with more than 50% polycarbonate content into monomers, closing the loop to a direct polycarbonate precursor. The technical implementation of chemical recycling is now beginning on a pilot scale at Leverkusen, where the process will be further optimized and will undergo further development. The pilot plant (kilogram scale), to be located in Leverkusen, will operate in a semi-continuous manner, with startup planned for 2025–2026. The company is investing "millions of euros" over the next few years.

Mechanical recycling of polycarbonate is already an important component of Covestro's recycling strategy, which aims to be fully circular by 2050. The mechanical recycling process is used whenever waste streams are sufficiently pure and the recycled polycarbonate meets the requirements profile of the future application. The new chemical-recycling process complements mechanical recycling, converting the plastic back into monomers, which can be separated and serve as raw materials for future plastic. Chemical recycling can therefore make larger waste streams that are unsuitable for mechanical processes accessible for recycling.

The company is investigation three alternative recycling routes, including enzymatic depolymerization and "smart depolymerization," a specialized and energetically optimized pyrolysis process, the company says. Unlike conventional pyrolysis, which breaks plastic waste down to smaller molecules, the smart pyrolysis targets high-value molecules that can be directly used in the production of new polymer.

MCR process uses approximately 30% less natural gas as compared to conventional reformer methods (for more on methane reforming, see Newsfront on pp. 13–17).

ETHANOL-TO-SAF

Last month, Lummus Technology LLC (Houston; www.lummustechnology.com) announced the commercial availability of its ethanol-to-SAF (sustainable aviation fuel) process technology. The technology provides operators with a large-scale, commercially demonstrated solution to reduce the aviation industry's greenhouse gas emissions.

Lummus' ethanol-to-SAF technology integrates ethanol-to-ethylene (EtE), olefin oligomerization and hydrogenation technologies in a process configuration that maximizes the final yield to SAF while minimizing capital and operating costs, and carbon emissions, the company says. Central to this process is Lummus and Braskem's technology partnership for producing green ethylene, which accelerates the use of bioethanol and supports the industry's efforts towards a carbon-neutral economy. Since 2010, Braskem has been operating an ethanol dehydration unit in Brazil. Using EtE EverGreen technology, the unit provides a proven and reliable foundation for produc-

(Continues on p. 10)

Solar cells integrated into car hoods

In recent years, some car manufacturers have developed vehicles that integrate photovoltaic cells into the roof — the easiest surface to use for onboard solar-power generation. Now, researchers at the Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE; Freiburg, Germany; www.ise.fraunhofer.de) have now gone one step further. As part of two publicly funded research projects, they have integrated solar cells into the standard sheet-metal hood of a regular passenger car. Coupled with ISE's MorphoColor technology, the solar-active surface can be color-matched to that of the vehicle. The technology was introduced last month at the IAA Mobility tradefair in Munich, Germany (September 5–11).

"We applied the solar cells to the hood panel of a car model that is frequently sold in Germany, interconnected them and laminated them with film," explains Martin Heinrich, coordinator for PV mobility at Fraunhofer ISE. "To achieve this, the lamination process was optimized to minimize air pockets, avoid wrinkling of the film module, which can occur due to the curved surface area, and to maintain the overall integrity of the hood structure."

The researchers constructed their prototypes using a selection of commercial solar cells (IBC, PERC shingle, and TOPCon shingle). In principle, any solar cell technology can be used. The 115-W rated vehicle-hood prototype exhibited at IAA Mobility features more than 120 PERC shingle solar cells and is finished in MorphoColor gray.

Together with partners from industry, Fraunhofer ISE developed the patented MorphoColor interface, which gives photovoltaic modules an intense color, while maintaining at least 90% of their efficiency. Besides cars, the technology can be used in building-integrated photovoltaic systems for colorful facades or brick-red roofs. The MorphoColor interface is a photonic structure in which an interference layer is combined with a geometrically structured substrate in such a way that a particularly narrow-band reflection maximum results. The module design is inspired by the Morpho butterfly. ■

ing 260,000 ton/yr of ethylene from ethanol. Lummus has integrated this world-scale dehydration process with its light-olefins oligomerization and advanced hydroprocessing technologies through Chevron Lummus Global, a joint venture with Chevron.

LOW-CARBON CEMENT

Last month, Terra CO_2 Technology (Golden, Colo.; www.terraco2.com) entered into a definitive agreement with Asher Materials (Southlake, Tex.; ashermaterials.com) for an exclusive market license of Terra's first commercial-scale advanced processing facility. Under the agreement, Asher Materials will acquire the plant, based in the Dallas-Fort Worth, Tex. market, after construction and commissioning are complete. The plant will produce 240,000 ton/yr of OPUS Supplementary Cementitious Material (SCM), which can substitute up to 40% of Portland cement in common concrete mixes and significantly reduce CO_2 and NOx pollution in the cement industry (*Chem. Eng.*, September 2022, p. 10). ❒

Plant Watch

OCI Global to double U.S. production capacity for 'green' methanol

September 14, 2023 — OCI Global N.V. (Amsterdam, the Netherlands; www.oci-global.com) plans to double its green-methanol production capacity to approximately 400,000 metric tons per year (m.t/yr) in Beaumont, Tex. The scaleup plans include entering into supply agreements for renewable natural gas (RNG). This will be OCI's first upstream RNG production facility. Production is slated to start in 2025.

Air Liquide announces investment in green-hydrogen production capacity

September 14, 2023 — Air Liquide S.A. (Paris, France; www.airliquide.com) is investing over €400 million for the construction of its 200-MW Normand'Hy electrolyzer project. This electrolyzer will deliver low-carbon hydrogen to TotalEnergies' petroleum refinery in Gonfreville, France starting in 2026.

Evonik expands production capacity for precious-metal powder catalysts in China

September 12, 2023 — Evonik Industries AG (Essen, Germany; www.evonik.com) has completed the relocation and expansion of its precious-metal powder catalyst plant in Shanghai Chemical Industrial Park (SCIP) in China. Production is scheduled to commence in late 2023. With this new plant, Evonik has completed the upgrade of its global network of five precious-metal catalyst plants.

Sabic and Sinopec start up PC plant at JV site in China

September 5, 2023 — Sabic (Riyadh, Saudi Arabia; www.sabic.com) and China Petroleum & Chemical Corp. (Sinopec; Beijing; www.sinopecgroup.com) began the commercial operation of a new polycarbonate (PC) plant at their 50-50 joint venture (JV) site, Sinopec Sabic Tianjin Petrochemical Co. (SSTPC). The new PC plant has a designed capacity of 260,000 m.t./yr. SSTPC's site also includes a mega-scale petrochemicals complex that produces polyethylene and polypropylene.

BASF begins construction of syngas plant in Zhanjiang, China

September 5, 2023 — BASF SE (Ludwigshafen, Germany; www.basf.com) has commenced construction of its syngas plant at the *Verbund* site in Zhanjiang, China. This world-scale syngas facility is scheduled to start up in 2025. The production technologies deployed in the syngas plant will mainly utilize CO_2 offgas, a byproduct of the ethylene oxide process, and excess fuelgas from steam-cracker operations to manufacture syngas.

LG Chem to expand RO membrane manufacturing capacity

August 28, 2023 — LG Chem Ltd. (Seoul, South Korea; www.lgchem.com) announced that it is spending 124.6 billion won ($94.1 million) over the next two years to expand the manufacturing facility for its key filter-membrane elements used in water desalination. The facility, located in Cheongju, South Korea, will have an annual production capacity of 400,000 reverse osmosis (RO) membranes, enough to desalinate 1.57 billion m.t./yr of seawater.

Sumitomo Chemical to begin mass production of ultra-fine alumina

August 28, 2023 — Sumitomo Chemical Co. (Tokyo, Japan; www.sumitomo-chem.co.jp) is set to begin mass production of ultra-fine α-alumina using a recently developed manufacturing technology. The new ultra-fine alumina products are characterized by homogeneous particles with a particle size of 150 nm or less.

Andritz starts up carbon-capture plant at Voestalpine steel mill in Austria

August 21, 2023 — Andritz AG (Graz, Austria; www.andritz.com) supplied its first carbon-capture plant to the steel industry. The pilot plant started operating at Voestalpine's steel mill in Linz. The plant separates CO_2 from the fluegases resulting from iron making using an amine-based process. The captured CO_2 is being delivered to an Austrian energy-storage company that is investigating new ways of making it available for reuse in steel production.

Mergers & Acquisitions

LG Chem and Eni exploring a joint biorefinery in South Korea

September 14, 2023 — LG Chem and Eni S.p.A. (Milan, Italy; www.eni.com) jointly announced that they are exploring developing and operating a new biorefinery at LG Chem's Daesan chemical complex. Final decision for the investment is scheduled by 2024 and the plant will be completed by 2026. The proposed biorefinery would be designed to process approximately 400,000 m.t./yr of bio-based feedstocks.

Repsol sells Canadian oil-and-gas assets for $468 million

September 12, 2023 — Repsol S.A. (Madrid, Spain; www.repsol.com) has agreed to sell its oil-and-gas assets in Canada to Calgary-based firm Peyto Exploration & Development for $468 million (approximately €433 million) as part of its ongoing portfolio management. The agreement encompasses all the mineral rights, related facilities and infrastructure of Repsol's Canadian oil-and-gas business,

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including the assets in the Greater Edson area in Alberta, which has a net production capacity of 23,000 bbl/d. Repsol retains operations in Canada through its St John LNG facility.

Fluor sells Stork business in Europe to Bilfinger

September 7, 2023 — Fluor Corp. (Irving, Tex.; www.fluor.com) agreed to sell its Stork business in Belgium, Germany and the Netherlands, as well as its turbo-blading manufacturing operation in the U.S., to Bilfinger SE (Mannheim, Germany; www.bilfinger.com). Stork mainly offers services in the areas of maintenance, modification and asset integrity.

Sabic sells its Hadeed iron and steel business

September 7, 2023 — Sabic has announced that Saudi Arabia's Public Investment Fund (PIF) signed a share purchase agreement to acquire a 100% shareholding in the Saudi Iron & Steel Co. (Hadeed), currently owned by Sabic. Based on a cross-conditional share-exchange agreement, Hadeed will also acquire a 100% shareholding in AlRajhi Steel Industries Co., in exchange for newly issued shares in Hadeed.

Albemarle confirms plans to acquire minerals firm Liontown

September 5, 2023 — Albemarle Corp. (Charlotte, N.C.; www.albemarle.com) confirmed that it will be working toward the execution of a binding agreement to acquire battery-minerals company Liontown Resources Ltd. (West Perth, Australia; www.ltresources.com.au). Albemarle's proposal values Liontown at $4.3 billion (A$6.6 billion) on an equity value basis. Liontown currently controls two major lithium deposits.

Technip Energies and Versalis combine recycling technologies

September 1, 2023 — Technip Energies N.V. (Paris, France; www.technipenergies.com) and Versalis S.p.A. (San Donato Milanese, Italy; www.versalis.eni.com), Eni's chemical company, have signed an agreement aimed at integrating Versalis' Hoop and Technip Energies' Pure.rOil and Pure.rGas purification technologies by developing a technological platform for the advanced chemical recycling of plastic waste. This collaboration aims to create a completely circular plastic-recycling loop, producing new polymers that are identical to polymers derived from fossil-based materials.

Teijin to sell its GH Craft composites business in Japan

September 1, 2023 — Teijin Ltd. (Toyko, Japan; www.teijin.com) has agreed to sell its entire stake in GH Craft Co., a subsidiary of Teijin's composites business in Japan, to TIP Composite Co., a manufacturer headquartered in Matsumoto City, Japan. Teijin acquired GH Craft in July 2008.

DuPont to divest 80% ownership in acetal homopolymer business

August 21, 2023 — DuPont (Wilmington, Del.; www.dupont.com) announced a definitive agreement to sell an 80.1% ownership interest in the Delrin acetal homopolymer business to TJC LP (New York, N.Y.) in a transaction valuing the business at $1.8 billion. ■

Mary Page Bailey

Methane Reforming: Solving the Hydrogen Blues

Improved catalysts and reconfigured reformer designs make steam-methane reforming the most scalable, industry-ready source of 'blue' H_2

IN BRIEF

For many decades, steam-methane reforming (SMR) has been, and still is, the technology of choice for the large-scale production of synthesis gas (syngas; a mixture of H_2 and CO), which is used for making a large number of chemicals, including ammonia, methanol, acetic acid, liquid fuels and more. When only H_2 is desired, such as for ammonia production, steel making and petroleum-refining applications, the CO in the syngas is "shifted" to CO_2 using the water-gas shift reaction (WGSR). In the past, the CO_2 produced from SMRs — both from the burning of fuel to heat the reformer tubes and the product from the reforming reaction — has been, for the most part, released to the atmosphere.

Now, with goals to reduce the global emissions of greenhouse gases (GHGs) taking center stage, efforts are underway to generate H_2 with a low carbon footprint. As a result, there has been a growing interest in water electrolysis as a source for "green" hydrogen. However, electrolyzers are still expensive, are not scalable to meet the large demands for H_2, and the availability of a reliable, inexpensive source of "green" electricity to run them is still not a reality. Until these issues hampering the shift to green H_2 are addressed, the medium-term solution is "blue" hydrogen — H_2 made by conventional reforming technologies, but combined with carbon capture, utilization and storage (CCUS).

FIGURE 1. This plant in Antwerp, Belgium is the first to use Air Liquide's SMR-X process. The plant started up in 2021

Improving SMR efficiencies

A first step for reducing CO_2 emissions from SMR (or any process) is to improve the overall efficiency. One example of a new-generation SMR developed by Air Liquide Engineering & Construction (Frankfurt, Germany; www.engineering-airliquide.com) is SMR-X technology. SMR-X is a new type of reformer that produces H_2 without excess steam, a byproduct that is declining in demand from users. Compared to conventional steam methane reforming, SMR-X features higher thermal efficiency at low steam co-production ratios and emits less CO_2.

Some of the notable advantages of this next-generation reforming technology are increases in the overall yield of the H_2 production process by roughly 5%, together with an intrinsic reduction of CO_2 emissions (pre-capture) of 5%, making it a reforming process with a significantly reduced carbon footprint.

In combination with Air Liquide's CO_2-capture technologies, like Cryocap, the SMR-X technology route can provide the lowest carbon intensities and highest conversion efficiencies, making it a key pillar for the energy transition and decarbonization projects, unlocking attractive H_2 routes for small- and medium-production capacities, says the company.

Air Liquide has been operating an industrial-scale plant (Figure 1) with this technology in Antwerp, Belgium since April 2021 and is said to be the first industrial-size greenfield recuperative-reforming plant in the world. The SMR-X technology is currently selected in many ongoing low-carbon H_2 concept and technology studies, as well as projects advancing to the front-end engineering and design (FEED) stage.

Catalyst developments are also leading

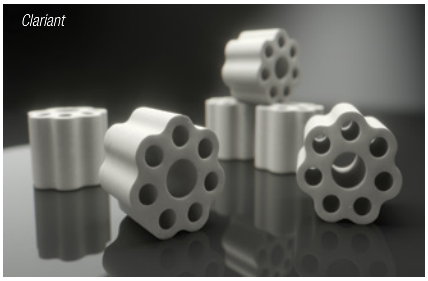


FIGURE 2. Clariant Catalysts' ReforMax LDP Plus SMR catalyst is said to provide a lower pressure drop than its predecessors

to improved SMR efficiencies. For example, BASF SE (Ludwigshafen, Germany; www.basf.com) developed the Synspire G1-110 catalyst, which reduces the steam demand for SMR (steam-to-carbon ratio down to 1.5) and maximizing the utilization of CO_2. BASF's new formulation is said to increase the coking resistance of the catalyst. Compared to standard SMR processes, the new catalyst can save up to 5% of operating costs, up to 3% of investment costs and decrease the CO_2 emission of the process by up to 13% by reducing demand for fuel, steam and electricity, BASF says.

Last month, BASF began construction on its syngas plant at the Verbund site in Zhanjiang, China. Scheduled to start up in 2025, the new plant will produce syngas and H_2 using "unique process concepts" to reduce CO_2 emissions, compared to conventional syngas plants, the company says.

Meanwhile, Clariant (Pratteln, Switzerland; www.clariant.com) recently introduced its new generation of ReforMax LDP Plus catalyst formulation (Figure 2) with high activity and 20% pressure-drop reduction. The reduced pressure-drop, without penalty on performance, leads to lower overall compression needs for the H_2 product gas and, hence appreciable energy savings, says Clariant Catalysts.

In addition, Technip Energies N.V. (T.EN; Zoetermeer, the Netherlands; www.technipenergies.com) and Clariant have introduced a new heat-recuperative reformer concept called enhanced annular reforming tube for hydrogen (EARTH, a tradename of T.EN) to improve the efficiency, capacity and sustainability of SMR. EARTH consists of an innovative concentric tubular structure and a tailor-made structured catalyst, which can be applied as a simple drop-in solution in existing or new reformer tubes. This unique setup results in superior heat recovery, higher throughput, and significantly lower pressure drop compared to conventional SMR.

EARTH can reduce CO_2 emissions by up to 10% and increase capacity by up to 20% compared to conventional SMR. EARTH has been successfully implemented at Ak-Kim's syngas plant in Turkey, resulting in fuel savings of 38%, higher radiant efficiency, lower steam export, and 20% lower CO_2 emissions. With the addition of process and fluegas carbon capture and other synergistic design changes, such as increased reaction severity to maximize hydrocarbon conversion and supplemental hydrogen firing, a CO_2 footprint reduction of more than 99% is achievable, says Clariant Catalysts.

Clariant also notes that, in the case of fluegas carbon capture, recuperative reforming brings significant advantages, because it directly translates into a smaller energy consumption and capital investment for the carbon-capture unit.

By investing in R&D and performing fundamental studies of the different carrier systems and their properties, Topsoe A/S (Lyngby, Denmark; www.topsoe.com) developed a new and more robust carrier system, which forms the basis for its Titan series of steam-reforming catalysts.

The Titan series of SMR catalysts, launched in 2020, is said to offer improved performance and longer catalyst lifetime thanks to the hibonite-rich composition. Prior to the launch, selected users experienced benefits of the Titan series, including 8% reduction in pressure-drop and 25% higher catalytic activity when compared to conventional catalysts available on the market.

The hibonite-rich composition of the catalysts provides a remarkable performance boost, which becomes especially evident after long operation. The addition of titanium promoters adds exceptional mechanical strength while a seven-hole cylindrical shape yields both a very low pressure drop and a high surface area. The catalyst's high activity and low pressure-drop leads to lower operating costs, increased profit margins and reduced energy usage, Topsoe says.

Meanwhile, "there has been an increase and more volatility in natural gas prices," says Ken Chlapik, market manager, Low Carbon Solutions, Johnson Matthey plc (London, U.K.; www.matthey.com). "This has increased the interest in pre-reforming applications, for which Johnson Matthey has developed Katalco 65-3X. This catalyst provides the same feedstock flexibility as other pre-reforming catalysts, enabling it to operate with a range of feeds, including ROG [refinery offgas], natural gas, LPGs [liquefied petroleum gas] and naphthas, however the catalyst uses new proprietary promotors to provide enhanced thermal stability. This enables the retention of a high catalyst activity deeper into the operating cycle, thereby enabling plants to confidently move to longer changeout cycles."

Also, because of higher natural gas prices, investment in new large plants has been scaled back and hence a shift to smaller projects including the revamp of existing units, Chlapik continues. "Structured catalysts, such as Catacel SSR, provide a perfect option for a low-cost means to improved efficiency and intensification of existing SMR. The structured form of Catacel SSR provides a step change in performance, where fundamental science limits further improvements in the design of randomly packed pellets. The structured catalyst is higher in voidage and GSA [geometrical surface area], thus providing a higher activity, but at a lower pressure drop. The catalyst is also designed to actively disrupt the boundary layer at the inner of the reformer catalyst tube

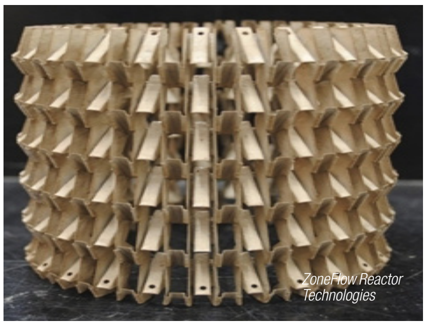


FIGURE 3. Pilot trials have sucessfully been completed on ZoneFlow's structured SMR catalyst

by jetting the process gas towards it, thus increasing the heat transfer coefficient. Together these features have provided our customers a 15% performance/throughput benefit, as well as a 15% saving in required firing fuel over a full catalyst lifecycle," says Chlapik (Catacel SSR technology was a finalist for the 2019 Kirkpatrick Chemical Engineering Achievement Award; see *Chem. Eng.*, January 2020, pp. 23–26).

In a related development, Honeywell UOP LLC (Des Plains, Ill.; uop.honeywell.com) and ZoneFlow Reactor Technologies, LLC (ZFRT; Windsor, Conn.; zoneflowtech.com) successfully conducted pilot plant testing of the ZoneFlow Reactor (Figure 3) in ZFRT's large-scale pilot plant at Université Catholique de Louvain in Louvain-la-Neuve, Belgium. The near-commercial-level testing validated increased steam reforming capacity by at least 15% in terms of feed flow compared to conventional state-of-the-art pellets, with no higher methane slip and without increasing the maximum tube skin temperature or pressure drop. This increased production of hydrogen allows for the SMR to convert hydrocarbon feeds, such as natural gas or naphtha, and steam into syngas.

In 2021, the two companies signed a joint development agreement to grow and commercialize the ZoneFlow Reactor technology (*Chem. Eng*., December 2021, p. 5). This technology can provide a significant improvement in the productivity and cost-effectiveness of SMR for H_2 and syngas production. "The combination of Honeywell's domain expertise and ZoneFlow's reactor technology is geared to provide high value creation for both new and existing SMR units. There are over 800 SMRs worldwide for H_2 generation and a similar number employed for ammonia and methanol production. The successful testing can allow for significant capital savings for new steam methane reforming plants and higher productivity for existing plants," says Ted Faiella, vice president and general manager of Equipment, Honeywell UOP Process Technologies. "As ZoneFlow's reactors can increase hydrogen production with existing assets, this ready-now technology can play a major role in the energy transition as refineries look to burn hydrogen instead of natural gas to lower their carbon emissions."

Blue hydrogen

In addition to improvement in energy efficiency, SMR technology providers have also been busy developing new concepts for making blue H_2. These innovative engineering designs have made it possible to capture 95% or more of the CO_2 from SMR units, compared to 60% achievable in older designs. As a result, "blue hydrogen is the most scalable and readily available low-carbon hydrogen technology on the market right now," according to a recent podcast of the John Wood Group plc (Wood; Aberdeen, Scot-

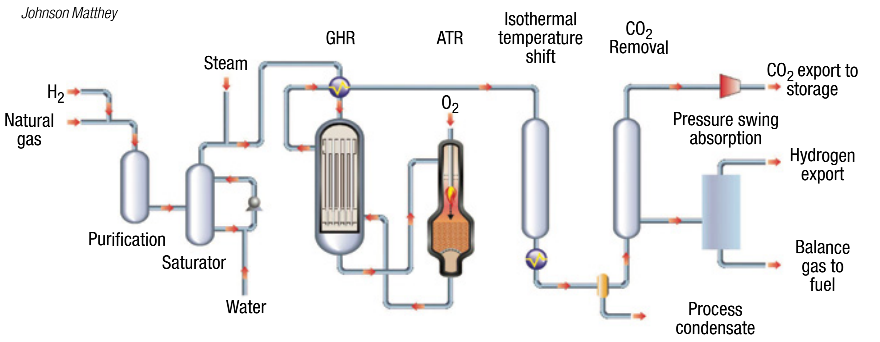


FIGURE 4. Johnson Matthey's LCH GHR-ATR flowsheet is said to be adept at producing hydrogen with very low CO_2 emissions

land; www.woodplc.com).

Last year, Wood introduced its BlueSMR technology, which revolves around the company's terrace-wall reformer, the core of its hydrogen technology, says Richard Spires, director of Technology Development at Wood. "With this technology, there is an even distribution and good control over how the heat reaches the reformer, and is the driver for improved efficiency," he explains. "For the reaction of steam and methane to give syngas, SMR is the closest to the thermodynamic optimum," he says.

A second point is integrating pre-combustion carbon capture with Wood's gas-heated reactor (GHR) design. "When done properly, it is possible to achieve greater than 95% carbon capture."

Wood offers three variants of its BlueSMR technology: BlueSMR, which introduces a number of upgrades including pre-combustion carbon capture, a GHR and a pre-reformer to significantly enhance unit performance. Hydrogen-rich gas firing will also displace the CO_2 emissions from the combustion side of the process; BlueSMR+, which is similar to the previous option, but with an improved catalyst-tube geometry in the reforming furnace, potentially leading to reduced operating costs; BlueSMRp, which involves installing a separate, parallel H_2-production unit with pre-combustion carbon capture to provide low-carbon fuel for the existing unit; and BlueSMRe, which integrates renewable electric power to decrease fuel consumption and CO_2 production.

In the past two years, approximately 90% of Air Liquide's SMR-based studies and projects requested from customers either included CO_2 capture or were partly fed by biogenic feedstock, so low carbon, the company says. Air Liquide is involved in a multitude of SMR-based, low-carbon H_2 studies, many of them moving towards FEED or project implementation phase.

One example is Air Liquide and TotalEnergies SE (Courbevoie, France; totalenergies.com) conversion of TotalEnergies' Grandpuits site into a biorefinery to produce and valorize renewable and low-carbon H_2. This H_2-production unit (20,000 m.t./yr capacity) will partly use biogas from the biorefinery built by TotalEnergies, and also leverage Air Liquide's Cryocap carbon-capture technology. These innovations will prevent emissions amounting to 150,000 metric tons of CO_2 a year compared to current processes, the company says.

Autothermal reforming

Conventional SMR utilizes a fired heater to produce the energy that enables the reaction to take place. This fired heater combusts natural gas and creates a low-concentration stream of CO_2 at atmospheric pressure. Although this can be captured, it requires large and expensive equipment and is harder to capture than CO_2 at process pressure, explains JM's Chlapik.

In comparison, autothermal reformer (ATR) technologies use oxygen to drive the reforming reaction instead of burning natural gas in a fired heater, Chlapik continues. This means in an ATR, there is not a separate low-concentration and low-pressure CO_2 stream from natural gas combustion and CO_2 can be removed from the process side at relatively high pressure and purity. This removal can be done with well-established CO_2 separation technologies and requires significantly smaller and, therefore, cheaper equipment. "Process side removal can be done in a conventional SMR, but would only provide CO_2 reductions of around 50–60% as it misses the additional combustion CO_2, he says. "In an ATR-based flowsheet, this technique can enable CO_2 reductions of up to 99%."

This means to produce CCS-enabled blue hydrogen, where reducing the maximum amount of CO_2 will be key to meeting stringent carbon-intensity standards, ATR-based flowsheets are a better fit than SMR. Johnson Matthey's Advanced Reforming technologies include ATR and gas-heated reforming (GHR), which are optimal for low-carbon hydrogen production. In particular, Johnson Matthey's LCH GHR-ATR flowsheet (Figure 4) is adept at producing hydrogen with very low CO_2 emissions. The exceptional efficiency of this flowsheet means it uses 10% less natural gas per unit of hydrogen compared to an SMR and therefore produces less CO_2 to be stored, which also enables a lower levelized cost of hydrogen, Chlapik says.

The high efficiency of the LCH process originates from the use of a GHR, which reduces the amount of combustion needed for the conversion of hydrocarbons and minimizes the size of thermal gradients in the flowsheet by transferring heat back into endothermic reforming reactions in the GHR rather than eroding high-grade energy by using it for steam production. By doing this, the fundamental energy efficiency of the flowsheet is maximized, Chlapik explains.

According to Air Liquide, ATR technology is particularly suitable for large capacities, whereby smaller capacities tend to favor SMR. The company sees clearly in the market a strong interest for ATR technology for these larger-scale projects, mainly driven by the following:

- Project capacities — often exceeding SMR single-train capacities
- Ease of decarbonization of ATR process (simpler decarbonization via

a single pre-combustion capture unit)

- Large-scale low-carbon H_2 and NH_3 co-production schemes, where an ATR-based setup is the most competitive route

However, there is still a strong market demand for SMR-based H_2 production technology (coupled with a strategy of decarbonization), mainly for: small- to mid-sized H_2 production linked to hydrotreated vegetable oil (HVO)/ sustainable aviation fuel (SAF) production, with a recycle of biogenic feedstock to the SMR for green H_2 production.

Other news

In July, KBR Inc. (Houston; www.kbr.com) and Air Liquide (Paris, France; www.airliquide.com) announced that they are now offering fully-integrated and flexible ATR technology for the production of low-carbon ammonia at mega scale. The offering combines KBR's ammonia-synthesis technology with Air Liquide's experience and proprietary ATR for large-scale syngas production.

When combined with carbon-capture technology, the KBR and Air Liquide technology solution will allow users to achieve "outstanding" energy efficiency and reliability, a simplified single-train production process, and up to 99% carbon capture in a highly integrated industrial facility.

Last month, Technip Energies, in partnership with Casale (Lugano, Switzerland; www.casale.ch), added Advanced ATR technology to Blue H_2 by T.EN — the company's suite of fully-integrated, low-carbon H_2 solutions. It is part of Capture.Now, T.EN's strategic platform for CCUS.

BlueH_2 by T.EN was launched last year (*Chem. Eng.*, December 2021, p. 5). Casale's ATR combined with Technip Parallel Reformer (TPR) and carbon capture is a cost-effective way to produce low-carbon hydrogen at large-scale with optimized steam production.

ATR is a game-changing technology as it breaks the upper capacity limit of traditional hydrogen plants, which were economically constrained by the size of the SMR, and enables large-capacity, ultra-blue hydrogen production with up to 99% carbon-capture rate.

"Our partnership with Casale means that Technip Energies, as a top-tier player with advanced ATR and SMR technologies, can provide its clients with a fully integrated solution to meet their decarbonization and performance goals at any scale and type of hydrogen plant," comments Loic Chapuis, senior vice president Gas & Low-Carbon Energies of Technip Energies.

In August, Lummus Technology LLC (Houston; www.lummustechnology.com) and Biohydrogen Technologies Ltd. (BHT; London, U.K.) established an agreement to develop and deploy advanced syngas reactor technology primarily for the production of blue H_2.

Lummus' Green Circle business unit will provide BHT its expertise in H_2 and syngas plant design, reactor scaleup and design, and proprietary equipment supply. The technology is said to have the ability to capture more than 99% of the CO_2 at pressure. ■

Gerald Ondrey

Data Analytics Software for Process Optimization

Advanced software solutions drill down through the data to provide actionable information

There is no shortage of data produced in a chemical processing facility, but sifting through the data to drill down to the useful information can be particularly cumbersome. Further, it is often challenging to understand what those data are trying to tell you and how that knowledge can be applied to create a plan of action that prevents inefficiencies, equipment downtime or process disruptions. Fortunately, today's advanced data-analytics software effectively present data analysis results in a format that is both understandable and actionable, which helps chemical processors shift from reactive to proactive process management and encourages optimization of the process.

"Employing data analysis is nothing new," says Josh Shupp, vice president of customer success with Northwest Analytics (Portland, Ore.; www.nwasoft.com). "People have been doing it for years using spreadsheets or standard historian-type software. What is different is that today's data-analytics software solutions apply meaning to the data, focus on key process indicators [KPIs] and encourage processors to use the data to find potentially impactful situations in advance, as opposed to reacting and 'firefighting'.

"Current solutions allow users to move away from using data analytics to figure out why there was a problem yesterday and begin monitoring and finding the problems before they affect production," he says. "It's like making chocolate chip cookies but waiting until you taste them to learn that they are burnt versus monitoring the temperature of the oven so you don't have to worry about burning the cookies again. Today's data-analytics software packages focus on prevention — seeing a problem and mitigating it before it negatively impacts the process, the equipment, the quality or the throughput" (Figure 1).

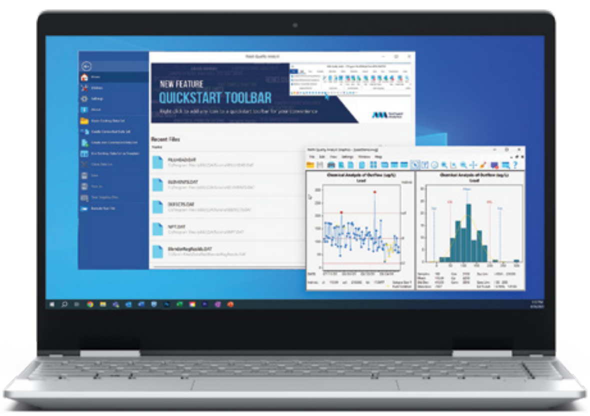
Helping to stay competitive

Smart processors are using data analytics software to monitor all sorts of impactful data in an effort to optimize the process, upgrade quality control, perform predictive maintenance, enhance safety and improve resource efficiency, all of which are becoming increasingly important as chemical processors struggle to remain competitive.

However, achieving these goals in today's fast-paced environment demands an advanced data-analytics platform that is capable of joining disparate sources to enable seamless analytics and visualizations, in addition to ad-hoc and highly polished reports, says Allison Buenemann, chemicals industry principal with Seeq (Seattle, Wash.; www.seeq.com). "Advanced analytics software provides the data connectivity, visualization and analytics capabilities needed to maximize uptime, improve quality and consistency and push throughput rates to meet production and sustainability goals," she says (Figure 2).

Andreas Eschbach, founder and CEO of Eschbach Software (Boston, Mass.; www.eschbach.com) agrees: "Better access to data improves decision making across all levels of the organization because analytical tools turn data from various sources into actionable, understandable information about plant status, processes and products. When everyone has access to the information they need to do their jobs effectively, they can make better operational decisions both individually and collectively, which drives continuous improvement across the organization, enabling optimization of processes, better quality control, increased throughput and improved asset utilization," notes Eschbach (Figure 3).

He adds that advanced data analytics solutions can help with virtually every aspect of plant performance, from environmental, health and safety (EHS) compliance to predictive maintenance decisions. "A centralized knowledge-management platform allows team members to learn from past events to optimize processes," Eschbach continues. "For example, operators can mine information from digital platforms to correlate variations in product quality to equipment parameters, batch timing or other variables. Often information that could be useful for troubleshooting, process optimization and planning is hiding in the vast amounts of data collected in a



Northwest Analytics

FIGURE 1. Northwest Analytics's Knowledge Suite helps processors identify early warning signals, codify institutional knowledge and take quick and decisive actions

Seeq

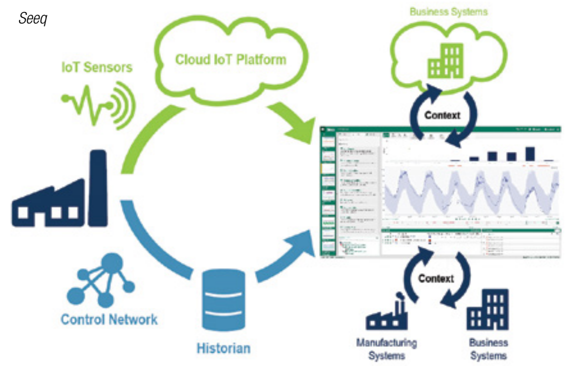


FIGURE 2. Seeq, an advanced analytics solution, combines the data from numerous subsystems to create enterprise-wide insights and facilitate data sharing specific to the level required by each software user

processing facility every day. Analytical tools and emerging AI [artificial intelligence] tools can help to surface this information and make it findable and usable."

Optimization and improvement

But how can chemical processors use data-analysis software to optimize their own operations and meet specific goals? "Data analysis and the associated software can play a significant role in helping chemical manufacturers achieve their goals, including optimizing and streamlining processes, increasing efficiency, reducing downtime and increasing throughput," says Keith Holdaway, global advisor for IoT at SAS (Cary, N.C.; www.sas.com). "Additionally, data analysis can contribute to several other crucial goals for modern chemical manufacturers" (Figure 4).

Holdaway suggests multiple ways that data analytics software can help processors achieve a variety of goals. For example, for processors who are looking for process optimization and efficiency, data-analysis software can analyze historical process data to identify inefficiencies and operational bottlenecks. "By leveraging advanced analytics, the software can suggest optimal process parameters to improve efficiency and reduce waste, because real-time data analysis allows for continuous monitoring and adjustment of process variables for ongoing optimization," Holdaway explains. Further, data analysis drives a culture of continuous improvement by providing insights for ongoing process optimization and performance evaluation.

Increases in throughput are also possible, because data analysis can identify opportunities to enhance production rates and reduce cycle times through process optimizations. "Real-time analytics can help identify production bottlenecks, allowing timely corrective actions to improve throughput," says Holdaway. And, data-analysis solutions can also help reduce downtime because real-time monitoring and anomaly detection can help uncover early signs of equipment issues, enabling proactive maintenance before breakdowns occur, reducing downtime and increasing availability of equipment to further enhance uptime and throughput.

He continues to say that product quality improvements are also possible. "Data-analysis software can also monitor and analyze real-time quality parameters, ensuring adherence to quality standards and early detection of deviations, so factors affecting product quality can be identified and adjustments to the process can be made for improved quality."

Energy efficiency and sustainability goals may also be achieved, according to Holdaway, because data analysis identifies energy-intensive processes and provides insights to optimize energy consumption and reduce emissions for sustainability goals. "It helps track environmental metrics, supporting efforts to reduce the carbon footprint and comply with environmental regulations," he says. Safety and risk management may also be enhanced as data analysis can identify potential safety hazards and deviations, aiding in proactive risk management.

The benefits

Although these sound like great applications, chemical processors may wonder if there are enough tangible benefits to be derived by employing data-analysis software versus sticking with more traditional methods of collecting and using data and the answer is "yes," according to experts.

"The obvious benefit of using data-analysis software and the one most ask about is a financial benefit," says Northwest's Shupp. "And that is certainly there, as optimizing the process and increasing throughput provide obvious financial benefits, as does the ability to detect maintenance issues or process anomalies early on. Even if the facility can't avoid downtime entirely, they are likely able to use the data to reduce downtime from days to a few hours and that's huge as the lost profit chemical processors can experience from downtime is significant."

Bob Rice, vice president of engineering with Control Station, Inc., (Manchester, Conn.; www.controlstation.com), which provides control-loop performance monitoring (CLPM) solutions that simplify the identification, isolation and correction of common regulatory control issues that negatively impact both process performance and plant profitability, says the ability of data analysis and CLPM solutions to increase throughput while also reducing waste and energy consumption is noteworthy. "Studies put gains in production throughput between 2% and 5%, with increases in yield topping out at 10%," says Rice.

In addition to improved productivity and operational and efficiency gains, there are "softer" benefits,

FIGURE 3. A centralized knowledge management center, such as Eschbach's Shiftconnector, helps team members communicate, generate ideas, preserve best practice information and apply them into chemical factory solutions

as well, says Eschbach, including error reduction and improvements in worker and process safety, better communication and accountability across teams and shifts, enhanced access to information for troubleshooting, continuous process improvements and quality control, and efficient reporting for compliance, strategic planning and daily operational decision making.

"In addition, centralized knowledge management preserves important institutional knowledge that is hiding in shift notes, maintenance logs and other disparate data sources," explains Eschbach. "As experienced workers retire, this becomes a valuable knowledge source for onboarding new workers and ensuring organizational continuity. Enhanced access to data and analytics empowers people in the plant to do their best work."

Applying analytics software

The key to successfully employing and reaping the benefits of data analytics software lies in selecting a solution that presents data in an actionable way and implementing it wisely. "By empowering knowledge workers with intuitive self-service graphics and dashboarding tools, data analytics software facilitates the seamless integration and utilization from various operational, business and IT systems, leading to more agile decision making," explains Sasha Jones, lead technical advisor, with IOTA Software (Raleigh, N.C.; www.iotasoftware.com). "The exceptional value comes from the ability to seamlessly connect with a diverse array of manufacturing data sources concurrently, making it an optimal solution for scenarios demanding holistic, cross-system visualization and comprehensive data aggregations" (Figure 5).

Jones continues: "Use cases may include condition-based maintenance enabled by connectivity, operational historians and asset management systems, as well as initiatives that involve predictive and prescriptive analytics that require the display of analytical outputs alongside current actual operating conditions. Real-time data-querying capabilities, along with the integration of asset attributes, batch and event conditions and relational systems, allow information to be brought together in specific context and by dismantling data silos, it mitigates the proliferation of redundant data copies, thereby aligning with and streamlining an organization's master data-management strategies."

FIGURE 4. For chemical companies, data analytics solutions, such as SAS Viya AI and Analytics platform, can help optimize and streamline processes, increase efficiency, reduce downtime and increase throughput

Seeq's Buenemann agrees: "Live data connectivity is essential. Without it, near real-time monitoring and predictive analytics use cases are not possible. Software that federates data sources simply by connecting to the source, indexing signal metadata and querying on-demand is a great alternative for those looking to avoid data duplication."

Buenemann adds that it's best to go for both "breadth and depth" when it comes to analytics capabilities. "Many software solutions go deep in one particular use case, but that leaves operations teams learning and IT teams maintaining dozens of applications to achieve operational excellence," she says. "An advanced analytics application that can go 90% of the way there in 100% of use cases will receive better adoption than numerous point solutions."

It is also important to ensure that the information is presented in a way that makes it useful, adds Phil Pearce, applications engineer with Northwest Analytics. "There are lots of data and a lot of analytical techniques, but none of that really matters if you can't make a decision," he says. "Data need to be presented in a way that is consumable by the particular user. Some of our customers have coined the term 'action boards' as opposed to dashboards, meaning that the information is presented in a manner where if something is signaling, you know you're supposed to take an action, not just see an informational-type beacon. Being able to tie the signal with the desirable action is the goal, so it's important that it is presented in an action board, message alert or some way that is overwhelmingly consumable, usable and actionable."

Control Station's Rice adds: "The distinction chemical processors should consider is the one between dashboards and diagnostics. Many applications in the analytics category are powerful tools, but they lack the diagnostic capabilities needed to proactively address common production-related challenges. So, be wary of just another dashboard. For sure, intuitive design is important and ease of use is essential, but users should expect their tools to include analytics and forensic capabilities that are based on actual domain expertise."

And implementing the chosen data-analysis solution in a chemical processing plant requires a thoughtful approach to ensure successful adoption and integration, according to SAS's Holdaway. He says the first step is to identify goals and objectives. "Define clear goals and objectives for using the software. Identify specific processes or parameters that require optimization or improvement," he explains. "This could be related to energy efficiency, product quality, process stability or another crucial aspect of the operation."

Gathering relevant historical data for the selected parameters is the next step, so it is important to ensure that the data are clean and consistent and in a format compatible with the software.

Once the initial leg work is done, Holdaway suggests starting with a pilot project. "Choose a critical process or parameter significantly impacting the plant's performance. This allows for a focused evaluation of the

FIGURE 5. IOTA Software developed VUE as a dynamic process visualization and analytics platform, able to seamlessly integrate data from all aspects of a business and empower users with intuitive self-service graphics and dashboarding

software's effectiveness," he says. "Next, perform data analysis using the software to gain insights into the selected process or parameter. This may involve exploring patterns, trends and correlations in the data. Develop appropriate models, such as statistical models or machine learning algorithms to predict behavior or optimize the process and then follow a repeatable and scalable suite of workflows."

Following this, the results should be validated by comparing them with the actual plant data and performance. Testing will ensure the accuracy and reliability of the models. Once the pilot project is successful, the data analysis software can be implemented in the selected area of the plant. "But monitor the project closely to assess the impact of the software's recommendations and optimizations," he says. "And then, as the data analysis software proves its value in the pilot project and selected area, expand its use to other critical processes and parameters in the plant. Gradually integrate the software into various areas of operation."

Once it has been successfully proven, adequate training and collaboration should be fostered among process engineers, data scientists and operators to encourage knowledge sharing and a deeper understanding of insights generated by the software. It is also essential to continuously refine and improve the data analysis models and encourage feedback from plant personnel to enhance performance and address specific plant requirements.

Finally, as the software becomes integral to the plant's operations, says Holdaway, explore opportunities to scale its use across the entire plant. Integration with other plant systems, such as process control systems, will help streamline data flow and decision making. Eventually users can develop a long-term strategy for using the software in the plant.

"By following a systematic approach, chemical processing plants can effectively start using data analysis software, gradually expand its use and derive maximum benefits in process optimization, cost savings and improved product quality," notes Holdaway. ■

Joy LePree

The Next Generation of Overpressure Protection

Overpressure protection is at the center of process safety across all chemical processing sectors. As processes and technologies evolve, it is essential that safety systems can adapt to provide the utmost levels of protection

All over the chemical process industries (CPI), almost regardless of the product being made or the material being handled, protecting against overpressure is of the utmost concern. Whether the situation involves a potential release of hazardous or toxic vapors, a runaway exothermic reaction or the formation of a potentially explosive dust cloud, there are numerous state-of-the art technologies available to help mitigate these dangerous situations. Alongside these commercial offerings, research institutions and standards organizations are ensuring that there are reliable pressure-relieving technologies for new and emerging processes. One organization at the forefront of dedicated research and technology development related to overpressure protection is the Mary K. O'Connor Process Safety Center at Texas A&M University (MKOPSC; College Station, Tex.; www.psc.tamu.edu). In this article, Faisal Khan, professor of chemical engineering and director of MKOPSC, discusses some of the most important safety issues facing the CPI, and gives some insight into what the next generation of smart pressure-relieving systems may look like.

Edison Sripaul, MKOPSC

FIGURE 1. At MKOPSC, a dust-explosion testing system helps researchers generate guidance for industrial processors to help them optimize their operating conditions to avoid dangerous situations

As a simple analogy to the critical nature of overpressure-protection systems to process operations, Khan brings to mind a car's braking system. "Can you imagine having a car without a brake pedal? Pressure protection in today's industrial plants, where we are pushing the limits in terms of operation, serves a similar purpose as the brake in the car. It provides broader operability to the system," he says. And like a car, he points out, alongside the conventional brake, you will also find an emergency brake. Similarly, within a pressure-protection system, there will also be elements installed that are uniquely designed for emergency conditions.

Digitalization

As with any operational function in the CPI, digital technologies and data analysis are becoming integral in overpressure-protection systems. The key benefit of digitalization in process-safety applications, says Khan, is its ability to reveal hidden risks and so-called gray areas where gaps in protection may exist.

"In any process there are certain elements that create some hidden risks. And while these risks could cause a significant impact or even catastrophic consequences, because their likelihood of occurrence is relatively low, they may remain hidden when compared to normal operating conditions," he explains.

In such highly complex instrumented systems as a typical pressure-relieving scheme, any type of failure can create a potential safety incident, but advanced digital technologies enable the study of vast numbers of overpressure scenarios in ways that were not previously possible. "Within the digital world, we can discover the boundaries of how and where systems fail and enable sufficient redundancy and operational control to minimize failures. Digitalization helps us to better understand those gray areas where we might see equipment fail," notes Khan.

He also emphasizes the importance of applied research and experimentation alongside advanced mathematical models to help guide safer industry practices. "We can set up experimental methodologies along with mathematical models to form basic tools that vendors and operators can use to interrogate and study their systems to find weak links. Our experimental facilities, along with our computational abilities, are able to create the methods that must be carried out, step by step, to understand the hidden risks, calculate and develop the models to help users to understand their associated risks and how they can follow strategies to minimize it. The outcome of our work is to set the stage for vendors and operators to better study their systems."

Ultimately, Khan says what the industry really desires is to effectively use their data to make informed safety decisions. "That's one of the things team members are working closely with industry to unleash."

Uncovering dust-explosion risks

One of the main hidden hazards in the CPI is dust, as many people may not understand the risks of dust explosions. Crucial to advancing the dust-control sector is to expand the industry's understanding of the conditions that can lead to dust explosivity — from the size of particles to the optimal operating conditions and what type of protection devices might be required (Figure 1). "MKOPSC works closely with industry to analyze data from many different substances to provide guidance about under which conditions dust could become explosive, therefore demanding the specification of an overpressure-protection system," states Khan.

One area where such guidance has changed drastically in recent years is in biomass-handling applications for converting solids, such as sugar or wood, into biofuels and bio-based chemicals. "The operating envelopes have changed significantly with new applications for biomass. Guidance can be as simple as changing the size of particles, or potentially specifying a device that can relieve excess energy levels in the system to avoid explosivity," he adds. According to Khan, the biomass-handling industries have learned a great deal over time and have built more robust systems to better avoid explosivity limits by maintaining certain operating conditions, while at the same time installing appropriate protection systems that will enable them to safely relieve pressures in case they must operate outside their normal conditions.

Emerging energy systems

As the world continues to explore lower-carbon energy options, such as battery energy storage and hydrogen, there are many challenges and process-safety risks that must be addressed. "In evolving fields, such as hydrogen and batteries, overpressure protection is one of the most important elements," says Khan.

Hydrogen — with its low ignition energy, propensity to leak and its detection difficulties — poses many unique safety challenges that must be addressed as larger volumes of hydrogen enter the energy landscape. "Hydrogen absolutely works in a totally different pressure domain than what we typically expose traditional protection devices to, so those systems may not be directly applicable to the particular environment where hydrogen operates," says Khan. More research will be required to provide more suitable overpressure-protection solutions, which not only must be vetted from a technical standpoint, but also must eventually be accepted by the public as safe. "One thing that is very clear is that overpressure protection systems for hydrogen cannot be open-release, which is very unique when compared to other hydrocarbons or fuels, where the protection system can provide safe relieving of the pressure to a relatively open atmosphere. Unfortunately, in the case of hydrogen, given its low ignition energy, its release to an open atmosphere is sufficient to ignite and create an explosion," explains Khan. To address this added complexity, work is underway to develop unique pressure-protection systems that direct the release into a safe, confined space. Otherwise, says Khan, the pressure-relieving action itself could be the source of an accident. "In a very simplistic system, you might have a full cylinder of hydrogen being transported, with an empty cylinder beside it in the event of a possible overpressure situation. Then you could use the second cylinder as the pressure-relieving system," he notes.

Batteries also have special characteristics that make them prone to overpressure events related runaway reactions and overheating (Figure 2). However, as battery systems are scaling up for utility-scale energy storage, there is still a need to develop proper overpressure protection for individual battery packs. "We are designing relief and overpressure devices to be as miniscule as possible at the pack level. This is a whole new dimension for overpressure-protection systems. The industry is working to design such systems now, not only to safely run battery systems at a larger scale, but to also monitor operation in abnormal conditions to relieve pressure and avoid major accidents." says Khan. Indeed, there have been significant commercial advancements in installing relief devices into individual battery pack systems, but incidents can still occur at very large scales. "We have witnessed quite a few major accidents at those levels of facilities due to overpressure and explosions, where a single pack experiences overpressure and ends up creating overpressure over the entire installation. We have a good understanding at the smaller scale, but at the utility level, there is still a knowledge gap," says Khan.

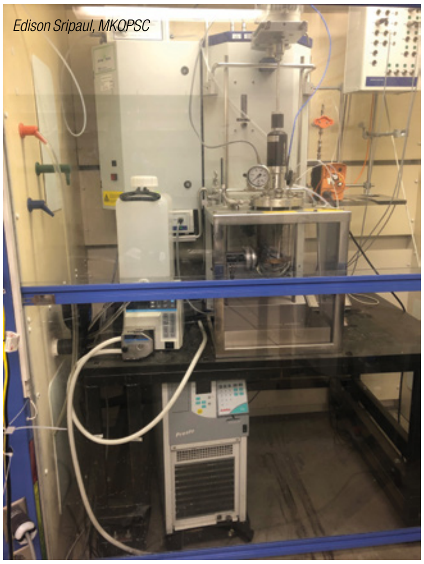


FIGURE 2. Experimentation using reactor calorimeters can help shed light on the conditions that can lead to runaway reactions, such as those seen sometimes in battery systems

The next steps

Considering the current state of overpressure protection, and looking ahead at the next generation, Khan sees sensors and process monitoring as key elements. On the horizon are devices that not only relieve or divert pressure buildup, but that minimize the pressure buildup itself. "This means that we are monitoring pressure conditions at the relief device such that they can operate on a continuous basis rather than based on a certain threshold." This enables a more circular system where material can be re-circulated through the device continuously to avoid pressure buildup in the system. "This is in stark contrast to current threshold-based models, where you allow pressure to build up within the system and then it is all released at once," Khan adds. ■

Mary Page Bailey

Compressors, Fans & Blowers

BOGE Kompressorem Otto Boge

Atlas Copco

Sensonics

Scroll compressors for sensitive work environments

This company has re-issued its EO Series of scroll compressors (photo) and expanded its performance range to 30 kW. The EO Series is very popular in sensitive work environments, such as when there is a high demand for oil-free use and process safety. The compressors are available in three sizes, from 4 to 7 kW, 11 to 23 kW and 30 kW. The design principle ensures the efficient generation of totally oil-free compressed air. The EO series is characterized by its particularly small footprint, even for the version with an integrated dryer. The compressor is also available with a compressed-air receiver, as a duplex system and with an integrated or external refrigerant dryer. Two-stage aftercooling ensures optimized outlet temperatures. The compressors have been designed for a pressure dewpoint of 3°C. — *BOGE Kompressoren Otto Boge GmbH & Co. KG, Bielefeld, Germany*
www.boge.com

Battery-driven portable screw compressor

The B-Air 185-12 (photo) is a new battery-driven portable screw air compressor. The B-Air 185-12 features 5–12 bars of pressure, a stable flowrate of 5.4–3.7 m^3/min and 55-kWh battery-storage capacity. With power delivered from its onboard power pack, a fully charged unit in operation is independent of the need for fuel or a local power source, and can perform for up to a full typical work shift. Making the switch from an internal combustion engine (ICE) to electric motor brings with it a host of benefits, including less downtime and maintenance requirements. Due to having far fewer moving (and therefore wearing) parts compared to a diesel-powered unit, the electric B-Air 185-12 only needs to be serviced every 2,000 h, as opposed to 500 h for a typical ICE-powered unit. The machine's variable speed drive (VSD) and permanent-magnet motor drives down the total cost of ownership, automatically adjusting the motor speed to match air demand in real time and increasing energy efficiency by up to 70%, the company says. — *Atlas Copco AB, Nacka, Sweden*
www.atlascopco.com

Monitor rotating machinery with this dual-channel device

Monitoring the dynamic behavior of smaller rotating machinery, such as gas turbines, pumps, motors, fans and centrifuges, has become increasingly important in today's highly competitive, cost-conscious environment. The DN26 G3 dual-channel protection system is a compact, DIN-rail-mountable unit for a wide range of machinery-monitoring applications. A recent delivery of 25 DN26 G3 dual-channel vibration monitors was made to a Middle East-based gas-transmission company (photo). At this site, these panel-mounted monitors are being used on existing turbine compressors in a gas pressure-booster station. They will be monitoring radial shaft vibration and axial shaft position on the compressor and, for the turbine, will be monitoring absolute casing vibration at both the gas generator and power turbine locations. — *Sensonics Ltd., Berkhamsted, Hertfordshire, U.K.*
www.sensonics.co.uk

Reduce compressor surge risk with this valve technology

Surge events can interrupt compression in upstream and midstream oil-and-gas, liquefied natural gas (LNG) and petrochemical facilities. If left unaddressed, this disruption may lead to compressor trips or system failures that require expensive remedial work to resolve damage, according to this company. To address these concerns, this company has developed an integrated anti-surge and compressor-recycle valve that combines multiple, co-acting technologies to balance efficient production and equipment health. The valve features the patented DRAG control valve technology with SC/V actuators and smart, high-performance FasTrak or QuickTrak controllers and positioners. These individual

parts continually interact to reduce the chance of cycle trips to optimize performance at startup and during operation. — *IMI Critical Engineering plc, Birmingham, U.K.*
www.imi-critical.com

These transmitters help improve availability and more

Introduced in March, Versatilis transmitters provide condition-based monitoring of rotating equipment, such as pumps, motors, compressors, fans, blowers and gearboxes. Versatilis transmitters perform relevant measurements of rotating equipment, delivering intelligence that can improve safety, availability and reliability across industries. These transmitters measure vibration, surface temperature and acoustics to anticipate rotary equipment anomalies. These measurements have additional applications, such as heat-exchange reliability and substation reliability. — *Honeywell Process Solutions, Houston*
www.process.honeywell.com

Two-stage, vertical-tank stationary air compressors

These two-stage vertical-tank stationary air compressors (photo) provide 175 psi and displace between 9.1 and 43.6 ft^3/min. Each compressor uses a heavy-duty, two-stage cast-iron pump and powder-coated, ASME-certified tank. A large flywheel provides for extra cooling and easier startup, while special unloading valves further assist the motor in starting. A directional air shroud helps reduce pump temperatures, and a thermal-overload protection feature prevents the motor from drawing too much current and overheating. The two-stage vertical-tank stationary line is powered by a one- or three-phase electric motor that provides between 2 and 10 hp. — *Jenny Products, Inc., Somerset, Pa.*
www.jennyproductsinc.com

Jenny Products

PD blower packages for pneumatic conveying systems

This company supplies a wide range of positive displacement (PD) continuous vacuum, pressure and vacuum/pressure system blower packages for conveying bulk materials (photo). Packages are available for 2- to 10-in. conveying systems. Each blower package includes a silencer and is supported on a heavy-duty base, allowing easy access for cleaning. Built-in braces permit the entire package to be moved into position with a forklift during installation or maintenance. Every blower package incorporates an industry-proven PD blower. The blower is dynamically balanced, and isolation pads are positioned between the blower and the base to reduce vibration and noise. — *Coperion K-Tron, Inc., Salinas, Kan.*
www.coperion.com


Coperion K-Tron

These blowers are energy efficient with a small footprint

The EBS rotary screw blower (photo) delivers flowrates from 10 to 41 m^3/min, with pressure differential up to 1,100 mbars and vacuum up to 550 mbars. The SFC version is equipped with an integrated frequency converter and a synchronous reluctance motor. EBS series machines have an energy-saving drive concept, and an intelligent and compact design, which allows all maintenance work to be carried out from the front side of the unit. This makes side-by-side installation possible, even when the complete electronics are installed. — *Kaeser Kompressoren SE, Coburg, Germany*
www.kaeser.com

Kaeser Kompressoren

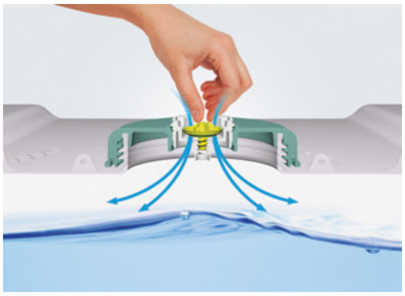
Compressor technology slated for Clean Energy Complex

This company will supply six air-compressor trains for Air Products' air-separation unit (ASU) as part of a new plant for the production of blue ammonia and hydrogen at the Clean Energy Complex in Darrow, La. The scope of the order comprises two main air-compressor trains — each equipped with a single-shaft compressor type, RIKT 160-3 (photo). It further includes two booster air-compressor trains — each with an integrally geared compressor type, RG 63-6 — as well as two gaseous-nitrogen compressor trains — each with an integrally geared compressor type, RG 45-5. All of the trains will be electrically driven. The main air-compressor trains have three centrifugal stages and deliver more than 600,000 Nm^3/h of air. The booster compressors are integrally geared types and have six (air) and five (nitrogen) stages, all with external intercoolers. — *MAN Energy Solutions SE, Augsburg, Germany*
www.man-es.com ■


MAN ENergy Solutions

Gerald Ondrey

New Products



Schütz

Busch Vacuum Solutions

Endress+Hauser

Kaeser Compressors

New breather system for enhanced food safety

The new CC/FC ventilation system (photo) is integrated into the bung of the screw cap that covers the filling opening of intermediate bulk containers (IBCs), enabling users to proactively avoid contamination risks. It is used to quickly and safely ventilate the container during emptying via the bottom outlet fitting and prevents negative pressure that would cause the inner bottle to become deformed. In previous systems, either the screw cap, which is often sealed, had to be opened or the bung plug had to be removed completely with tools in an additional process step. With the CC/FC Breather, users simply twist a screw part manually to open the venting paths in the component. This also minimizes the risk of contamination during the entire emptying process. — *Schütz GmbH & Co. KGaA, Selters, Germany*

www.schuetz.net

This new vacuum pump optimizes operating conditions

The Cobra DX 0950 A (photo) is the first vacuum pump to be released as part of the new DX Series. Cobra DX 0950 A is a dry vacuum pump with advanced screw-vacuum technology for excellent running characteristics, high vapor and particle tolerance and energy-efficient operation. The new pump is suited for many rough- and medium-vacuum applications, such as lithium battery production, drying, food packaging, coating and vacuum furnaces, or as the heart of a central vacuum system. An optimal vacuum level can be achieved at all times thanks to the intelligent driving unit with variable-speed control and various operating modes. This reduces energy consumption and ensures that the vacuum pumps run under optimal conditions. In addition, the patented self-balancing screw design of Cobra DX 0950 A ensures low vibration levels and quiet operation. The screws are made of one single casting and have no gaps. This prevents the ingress of process fluids or particles, as well as corrosion and deposits. — *Busch Vacuum Solutions, Virginia Beach, Va.*

www.buschvacuum.com

A new gateway for secure communication of field devices

FieldGate SWG50 (photo) is a new WirelessHART gateway primed for secure communication from field devices, providing an easy-to-use solution for multiple-standard monitoring applications across various industries. FieldGate SWG50 is compact and designed for integration with Netilion, a cloud-based IIoT ecosystem designed for industrial processes, connecting the physical and digital worlds to send information from the field straight to a smartphone, tablet or another device. FieldGate SWG50 enables users to monitor measurements and health status using WirelessHART connectivity. This offering is an economical alternative to complex and costly cable installations, reducing expenditure for process automation by up to 30%, the company says. — *Endress+Hauser, Inc., Greenwood, Ind.*

www.us.endress.com

New compact, variable-speed reciprocating compressors

The new i.Comp 8 and 9 oilless compressors (photo) are available in two sizes and three configurations (G, Tower and Tower T). The i.Comp units deliver oil-free air at up to 160 psi and 20 ft^3/min. The direct-drive motor and oilless design eliminate nearly all routine service. Pressures can be precisely adjusted to each application's requirements with the company's Sigma Controller 2. i.Comp compressors are also available as Tower configurations, which include a receiver and drain trap, while Tower T configurations include a refrigerated dryer. A small footprint and low noise make i.Comp suitable for use in tight spaces. — *Kaeser Compressors, Inc., Fredericksburg, Va.*

www.us.kaeser.com

A new hydraulic bulk-bag conditioner streamlines workflow

A new Block-Buster hydraulic bulk-bag conditioner (photo, p. 28) features arched doorway masts that increase overhead clearance for easier insertion and removal of palletized bulk bags using a forklift. The conditioner loosens hygroscopic chemicals, spice blends, heat-sensitive products and

Flexicon

BOGE America

GEA Group

Pepperl+Fuchs

other bulk materials that have solidified during storage and shipment, returning the material to a free-flowing state and enabling bulk-bag unloaders to discharge the material through bag spouts. A hydraulically-actuated, variable-height turntable operates in concert with two hydraulic rams to press opposing sides of the bulk bag at varying heights, rotate the bag 90 deg and then repeat the conditioning cycle. The number and pressure of hydraulic ram actuations, the height of the turntable and the number of 90-deg rotations are user-programmable at the control panel's human-machine interface (HMI). — *Flexicon Corp., Bethlehem, Pa.*
www.flexicon.com

Heat recovery saves energy with this compressor setup

When this company's heat-recovery components (photo) are installed onto an air compressor, up to 94% of the energy used to compress air is recovered. This recovered energy can be used to heat storage and operating areas or for heating water or oils. For example, the heat can be used for the treatment of drinking water, service water, heating water and process water. The latter is used for industrial washing processes, for example in recycling processes to clean plastic and synthetic materials. Heat-recovery components can be used to recover heat in both oil-injection-cooled and oil-free screw compressors. At the same time, the energy for cooling processes within the compressor is reduced, because the heat generated is conducted away and used elsewhere. The investment in heat-recovery components pays for itself within a few months depending on the application. — *BOGE America, Inc., Powder Springs, Ga.*
www.boge.com/en

Twin-screw pump for conveying and cleaning

This company launched a new generation of twin-screw pumps for food, beverage and pharmaceutical applications that combine both the conveying and cleaning functions in one pump. The revamped Hilge Novatwin+ twin-screw pump (photo) is more powerful than its predecessor series, and thanks to its higher flowrate, covers a wider range of applications with a smaller pump. Users not only reduce their material footprint by 23% with the new design, but also reduce energy demand by 10% due to the improved efficiency. With variable speeds of up to 3,000 rpm, the self-priming positive-displacement pump conveys lumpy, shear-sensitive and abrasive media particularly gently. It can handle liquids with a wide range of viscosities. Since the Novatwin+ pumps operate with nearly no pulsation, they are also suitable for large and sensitive particles. Twin-screw pumps can also serve as clean-in-place (CIP) pumps, because they can be operated at very high speeds. The system pressure of 30 bars also allows for use in high-pressure applications. — *GEA Group, Düsseldorf, Germany*
www.gea.com

Comprehensive solutions for level measurement

Vibration limit switches reliably detect the fill level of liquids at all times. With Vibracon LVL-M3 and -M4 (photo), this company offers two new series of vibration limit switches that can be used worldwide in hazardous areas due to ATEX and IECEx approvals. The LVL-M3 version is suitable for universal use in all pumpable liquids. The vibration limit switch can withstand process temperatures of –40 to 150°C and process pressures of up to 40 bars. The LVL-M4 version is suitable for safety applications up to SIL 3. The sensor is resistant to process temperatures of –50 to 150°C and process pressures up to 100 bars. The LVL-M4 version has a Bluetooth interface that can be used to connect the device to the company's Level App. This mobile application enables status and fault indication to proof testing. — *Pepperl+Fuchs SE, Mannheim, Germany*
www.pepperl-fuchs.com

Connectors with lever push-in technology

This lever technology (photo, p. 29) enables fast and effort-saving multiple wiring of different conductor types with and without ferrules. The connectors are simply integrated into the function shaft of the terminal blocks. Various tests can be carried out quickly and

easily with the LPS service connectors. The contact springs have a silver-plated surface to ensure permanent and consistent quality. The company's LPO load-contact connectors enable the easy integration of additional load contacts. This means the LPO connectors provide a significant advantage, especially if design changes are necessary in the control cabinet. The special design enables a durable and robust connection. The new connectors feature maximum ease of use, a secure connection, high flexibility and fast installation. — *Phoenix Contact GmbH & Co. KG, Blomberg, Germany*
www.phoenixcontact.com

New two-level terminals for 4-mm^2 cross-sections

This company has introduced new space-saving two-level terminals for rated wire cross-sections up to 4 mm^2. The compact PRKD 4 terminal blocks and the corresponding PSLD 4 PE terminals (photo) are available with two or three ports per level and halve the required installation space. In addition to the small footprint, both series are characterized by a large variance and particularly easy handling due to enlarged insertion channels and minimized engaging force. An integrated pusher, which can be operated with light pressure without special tools, is used to quickly disconnect wires. The terminal design and vertical wire insertion from above enable installation close to the wiring channels and thus very compact setups in the field. The high contact force of the push-in spring ensures secure fixation of the wire ends that withstands even strong vibrations and mechanical shocks. — *Conta-Clip Verbindungstechnik GmbH, Hövelhof, Germany*
www.conta-clip.com

Bin activators are designed to enhance solids handling

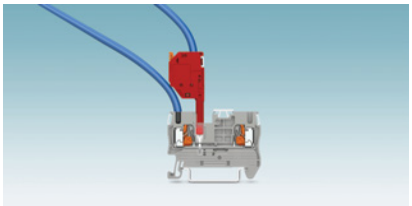
This company's Bin Activators (photo) help to eliminate bridging and ratholing in bulk-solids handling applications. They also reduce particle segregation and promote improved mass flow. The company offers a number of Bin Activator designs to meet a wide range of processing requirements: the original Dished Head design; the Model HDBD, which uses a compound slope body; and the Rolled Cone Bin Discharger design. For trouble-free installation, a pre-assembled mounting ring is offered. A patented beaded sleeve helps to avoid issues related to leakage and slippage. Users can choose from oil- or grease-lubricated vibrators for their system. — *Vibra Screw, Inc., Totowa, N.J.*
www.vibrascrew.com

Recycle exhaust air and reduce energy costs

The new Vibro-Bed Energy Recovery System (ERS; photo) is an exhaust-air recycling system engineered to help material processors lower energy costs, reduce unpleasant odors and curb emissions. The Vibro-Bed ERS can be retrofitted onto this company's and competitors' fluidized-bed drying systems or added onto new equipment installations. A partial-loop drying system, ERS recycles a portion of the heated air exhausted by the fluidized bed, while removing excess water vapor from the airstream. A programmable logic controller (PLC) opens and closes a series of back-draft dampers, forcing the previously heated air back into the fluidized-bed dryer. Ideal applications for the ERS include those with exhaust-air temperatures that exceed 150°F (66°C); or large particle sizes that do not release moisture easily; or low drying rates for materials that have bound moisture content, such as grains, fruits and vegetables. — *Kason Corp., Millburn, N.J.*
www.kason/com/fluid-bed

New headgear models merge comfort and safety compliance

Four new safety helmets have been released as part of the Skullerz product line, including models with adjustable venting and rechargeable three-mode LED headlamps (photo). The newly developed Type 2 safety helmets provide comprehensive protection, offering safeguards to the top, front, side and rear of the head to meet the stringent ANSI/ISEA Z89.1-2014 (R2019) Type 2 requirements — all without compromising on breathable comfort, a major point of concern among other Type 2 headgear, says the manufacturer. — *Ergodyne, St. Paul, Minn.*
www.ergodyne.com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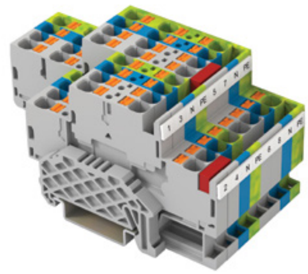
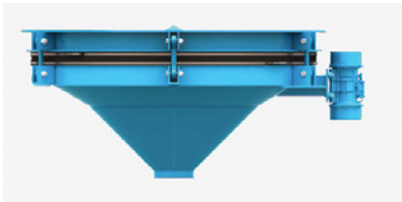

Conta-Clip Verbindungstechnik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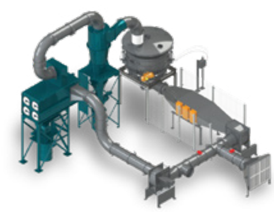
Kason


Ergodyne

Pioneer Pump, a Franklin Electric Co. brand

These pumps can handle challenging solid materials

The Vortex Series of pumps (photo) are designed for handling abrasive wastes. Using a recessed impeller design, the series combines the efficiency characteristics of a self-priming pump with the solids-handling capabilities of a chopper pump. This makes it suitable for applications that need to pass solids while also handling flows to meet the application's high total dynamic head (TDH) and gallons per minute (GPM) requirements. Recessed impellers assure that only about 15% of the solids that pass through the pump come into contact with the impeller, according to the manufacturer. Combining this impeller design with a vacuum-assisted priming chamber allows the pump to move both solids and fluids efficiently. The priming system also ensures rapid and unattended re-priming, and the run-dry lubrication system avoids premature failure of the seal and rotating assemblies. — *Pioneer Pump, a Franklin Electric Co. brand*

www.pioneerpump.com

Baumer

An extremely small ultrasonic sensor

The new UR12 ultrasonic sensor (photo), in M12 size, is said to be the world's shortest ultrasonic sensor, featuring a housing reduced down to a length of just 50 mm, along with a 15-mm "blind" area. These sensors provide a response time of up to 16 ms with a maximum detection range of 500 mm (1,000 mm for through-beam sensors). This allows design engineers more freedom in space-saving machine designs. As standard, the sensor features IO-Link interface for easy integration and delivery of valuable secondary data, while advanced functions ensure optimum sensor settings, such as easy configuration of sonic cones using this company's Sensor Suite platform. For less demanding distance measurement applications, a retrofit product variant of is available without IO-Link. — *Baumer Ltd., Swindon, U.K.*

www.baumer.com

KBC, a Yokogawa Company

Optimize operational strategies with this flow-assurance software

Maximus 7.4 software (photo) is a multiphase flow tool that simulates thermohydraulic conditions to help improve design and operational capabilities for sustainable energy projects, including carbon-capture and storage (CCS) applications. Maximus 7.4 flow-assurance software is equipped with integrated production-modeling capabilities that help production engineers optimize design and operational strategies to improve decision-making, asset performance and profits while reducing risks. Maximus 7.4 software assesses production risks, such as solid formations (hydrates, waxes, asphaltenes and scales), as well as facility erosion or corrosion. Improved compositional modeling seamlessly integrates Multiflash technology into Maximus software, enabling precise simulation of complex fluid flows for hydrogen, geothermal energy, liquefied natural gas (LNG) and CCS, as well as oil-and-gas production and transport. — *KBC, a Yokogawa Company, Houston*

www.kbc.com

Stahlin

Low-profile enclosures provide maximum mounting space

PolySlim low-profile enclosures (photo) accommodate existing panel designs, eliminate unneeded depth and material, optimize installations and save space. The low-profile design of PolySlim enclosures makes them suitable for use on building exteriors and in tight spaces. They protect equipment in non-hazardous industrial applications where space is a premium, and safeguard network components, such as routers and switches, in harsh conditions. PolySlim enclosures are well-suited for electrical control, wireless communications, measurement, monitoring and security applications with minimal-depth equipment. PolySlim polycarbonate enclosures are available in seven sizes and can be configured with a hinged-screw cover or a hinged-latched cover. PolySlim enclosures feature a nonmetallic hinge that does not penetrate the inside of the enclosure. Thick and smooth side-wall construction eliminates flexing and maximizes fitting mounting space. Additional benefits of PolySlim enclosures include inhibitors that protect against ultraviolet degradation. — *Stahlin, Belding, Mich.*

www.stahlin.com ■

Mary Page Bailey and Gerald Ondrey

Bolted Flange Joint Assemblies

Department Editor: Scott Jenkins

Flange-bolted joints enable connections of singular segments of pipes into more complex sections, as well as joining measuring and process devices, such as flowmeters, pumps, fans and pressure vessels. These joints are potential sources of leakage, which can introduce safety and environmental hazards, as well as process inefficiencies. This one-page reference reviews concepts associated with preventing leaks in flange-bolted joints.

Design considerations

The design of flange-bolted joints depends on the selection of a gasket, as well as the proper assembly. Required design data include the nominal diameter of the pipeline, the temperature and pressure of the process fluid and the chemical and physical properties of the transported medium. Additional data are external loads on joint (and their variations in time), required tightness and durability of the joint. Over the past several decades, computational algorithms have been developed to help achieve the desired bolt tightness. In most cases, the algorithms apply to flange-bolted joints with circular gaskets, and the results of the calculations provide the torque at which the nuts should be tightened to ensure sufficient tightness [*1*].

Forces on joints

Three main forces act upon a bolted flange joint assembly (BFJA; Figure 1). The flange/bolt load acts to compress the gasket enough to fill any serrations or imperfections on the sealing surface. This helps prevent potential leak paths. The hydrostatic end load, caused by the internal pressure of the fluid in the system, acts to push the two flanges apart. The internal blowout pressure acts upon the gasket and tries to push it out through the gap between the flanges.

A main concern surrounding the design and installation of the BFJA is determining the gasket stress or load that will be applied to the gasket (the flange/bolt load minus the hydrostatic end load). This remaining gasket load must then be greater than the internal blowout pressure to ensure the integrity of the seal. If it is not, a leak or gasket blowout can occur [*2*].

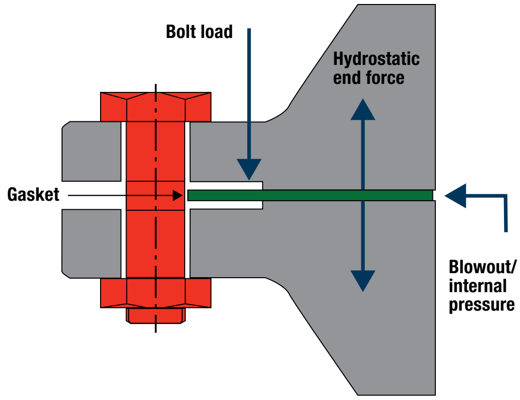

FIGURE 1. The three main forces at play in a bolted flange joint assembly (shown here) act to prevent leaks and gasket blowouts

Leakage rate

The leakage rate refers to the quantity of fluid that passes through the body and over the faces of a gasket per unit periphery of the gasket over a specified time [*3*]. The leakage rate is highly influenced by process media, pressure, temperature, surface pressure and other factors. It is usually measured under a specific gasket load and at a specific fluid pressure. For given set of conditions, the lower the leakage rate, the better the fluid is retained by the gasket material.

As a general guideline, increasing internal pressure leads to higher leakage rates. Increasing surface pressure results in lower leakage rates. Increasing molecular size generally means lower leakage rates. Increasing temperature gives lower leakage rates for some gasket materials, although toward the end of service life, the leakage rate is likely to increase [*3*].

Installation tips

The following are tips to consider when installing BFJAs [*2*].

- Make sure the flange sealing surfaces are clean and free of dings, marks or indentations
- Flanges should be aligned to maximize sealing contact and to provide a uniform gasket load
- Working surfaces of bolts, nuts and washers should be lubricated to ensure uniform friction
- Verify the material, grade and condition of the bolts. Nuts should spin freely onto the bolt thread without binding
- Number and tighten bolts using a proven tightening sequence or assembly pattern, and use a calibrated torque-control device to ensure proper torque values are applied
- Keep assembly records to verify that proper procedures were followed

Gasket materials

Common gasket materials include elastomers, polytetrafluoroethylene (PTFE), flexible graphite, natural fibers or mineral-based materials. Gasket manufacturers provide pressure-versus-temperature charts to help determine whether or not the material is safe to use for a particular application.

Flange compressibility

Flange compressibility is considered to be the percentage reduction in thickness of a flange under compressive pressure (applied at a constant rate, at ambient temperature). This value provides a means to measure the deformation properties of a gasket, and is an indication of the ability of the material to conform to the flange surface irregularities [*3*]. Gasket materials with higher compressibilities will more effectively fill surface roughness. ■

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Proactive Industrial Hose Maintenance

Proper hose maintenance can prevent failures, increase profitability and improve safety

Alice Chin
Swagelok

IN BRIEF

SETTING UP A PROACTIVE MAINTENANCE PLAN

IDENTIFY ALL HOSES

TRACK THE LIFECYCLE OF EACH HOSE

ELIMINATE HOSE STRAIN

ARE PROTECTIVE COVERS REQUIRED?

INSPECTION AND REPLACEMENT

ANALYZE YOUR DATA

BE PREPARED WITH SPARES

Deciding when to change industrial hoses is a common challenge facing plant managers and engineers — and it is a challenging decision for good reason. If plant managers wait too long to replace hoses, the hoses may fail and cause safety issues and unplanned downtime. On the other hand, replacing those hoses too early may cost a plant unnecessary time and money. Therefore, finding the right balance for proactive hose replacements is key. But it will take some work to determine the appropriate timing.

An excellent starting point for optimizing hose replacement schedules is for plant managers and engineers to create preventive hose-maintenance plans. Such plans should include tracking the life and performance of each hose, which will help plants zero in on appropriate replacement intervals. In addition, such plans should include protocols for making frequent inspections, proactively replacing specific hoses, and identifying which hoses to have in stock in case of failure. It may seem daunting to create this sort of comprehensive plan at first, but the long-term savings potential for a facility makes it worth the effort.

Remember that each hose will face its own stresses and strains depending on its application, which means replacement intervals will vary by environment and exposures (Figure 1). Factors like pressure, movement demands and which equipment is nearby will affect how hoses wear and must be considered when designing preventive maintenance plans.

For example, a facility may have a specific application that uses 50 identical hoses, 50% of which wear out after one year. The other 50% may last five times as long. Despite the fact the hoses are identical, it is impossible to set a replacement schedule based on their construction. Replacing them all after one year may be cost prohibitive, while waiting five years in between replacements could result in at least half the hoses experiencing failures.

FIGURE 1. Determining which hose is appropriate for specific applications depends on the specific criteria necessary for the application. Using an improperly reinforced hose could result in early catastrophic failure

As a plant manager surveys the situation and tracks the performance of each hose, it makes sense to replace the 25 hoses that experience accelerated wear each year, moving the second set of hoses to a five-year replacement plan. If each hose costs $200, this approach could save the plant $20,000 in direct costs per year, not including the value of reduced downtime and maintenance. That is a significant savings potential that demonstrates why facilities should seriously consider establishing and adhering to a preventive hose-maintenance plan.

Setting up a proactive maintenance plan

Start with the recommendations of your hose supplier when developing a preventive maintenance schedule, but also supplement those tips based on a real-world understanding of operating environments, hose materials and other factors. Do not guess how long the hoses will function properly. Effective plant managers should observe their hoses carefully over time and record changes to

determine what the right replacement interval should be for specific hoses. Below are the key steps plant managers should take to help create a proper preventive hose-maintenance schedule.

Identify all hoses

Before creating your plan, it is crucial to understand what hoses are in the plant. That means conducting a full plant audit, tagging each hose, and creating a log detailing the full roster of hoses. For each one, include information, such as the hose type, part number, process fluid contained inside, pressure or temperature ratings and which vendor supplied the hose, along with the appropriate contact information. This information will be handy for not only tracking hose performance, but also for ordering replacements.

In addition, plant managers should log other information like the hose's length, size, core material and construction, reinforcement layers, end connections, mounting, cover type, operating conditions and cleaning procedures. Finally, records should be kept that indicate when a hose was installed and when a replacement is scheduled. If nothing else, these steps will offer significant information on how well a plant is operating. If the process seems overwhelming, a reliable hose supplier should be able to help perform the audit and offer recommendations about what needs to be done.

Track the lifecycle of each hose

Schedule hose inspections at the interval recommended by the hose supplier. More often than not, these inspections may be visual and do not require system downtime. During such routine inspections, employees should examine hoses for scrapes, cuts, corrosion, kinks and general deterioration, which may provide an indication that it is time to replace the hose. Record all observations in the maintenance spreadsheet. If it is determined that it is time to change the hose, the service interval should be noted for future reference. Over time, understanding these intervals allows plant managers to replace hoses before they fail.

If a hose does fail despite regular inspections, employees should note every detail, including the location of failure on the hose, how severe the break was and how the hose was mounted. Recording such information provides a roadmap for determining why the hose failed and how to prevent a similar problem in the future.

Eliminate hose strain

Hoses can come under undue strain during their operation due to several common circumstances, including the following:

- Twisting a hose or bending it on more than one plane (Figure 2)
- Bending the hose beyond its recommended radius (Figure 3)
- Bending too close to the hose/fitting connection (Figure 4)
- Allowing insufficient hose length so the hose is strained during impulses (Figure 5)
- Failing to use elbows and adapters to relieve hose strain on horizontal end connections (Figure 6)

During regular inspections, employees should pay particular attention to any unusual circumstances that may be putting unexpected strain on the hose body. If hoses are rubbing against other equipment, experiencing pulses, are subject to external heat sources or are installed in strain-inducing configurations, remediate those conditions immediately. If left unchecked, they could reduce the lifetime of a hose or, in some cases, cause outright failure.

Are protective covers required?

In some cases, hoses require protective covers, including the following:

- Thermosleeves, which protect hoses from weld spatter and resist deterioration from ultraviolet light
- Fire jacketing, which protects hoses from temperature extremes posed by internal system fluids
- Spiral guards, which protect hoses against abrasion
- Armor guards, which keep hoses from kinking and experiencing abrasions
- Spring guards, which also help to minimize kinking and abrasions

Importantly, hose covers do not alter the technical data provided by suppliers. Before deploying a hose cover, it is crucial to understand the operating temperature of each option and what the cover does effectively. For example, thermosleeves may keep hoses safe from weld splatter, but it will not protect them from abrasion.

Inspection and replacement

As replacement intervals reveal themselves over time, a preventive-maintenance schedule will eventually come into focus. Though replacement intervals may offer good information about when a hose may need to be replaced, periodic inspections are still essential. In the dynamic world of

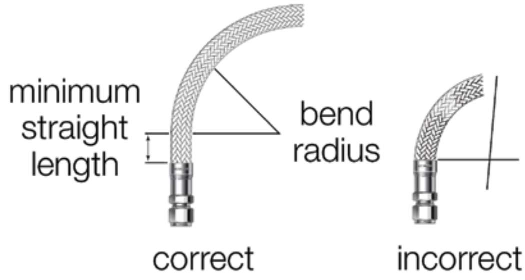

FIGURE 3. Exceeding a hose's recommended bend radius can produce undue strain and even result in premature failure

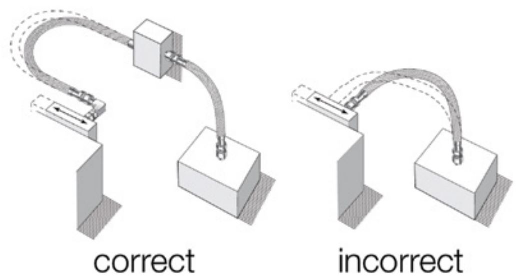

FIGURE 2. Strain can occur when a hose is twisted or bent on more than one plane

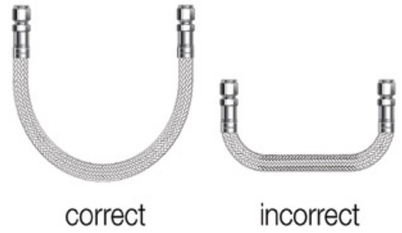

FIGURE 4. Always ensure a hose is bent far enough away from the fitting connection to prevent shortening a hose's useful life

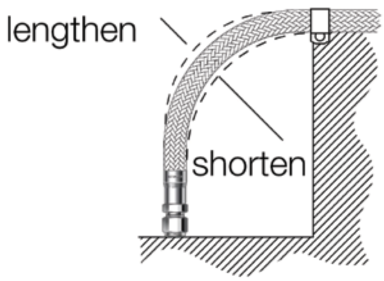

FIGURE 5. If a hose is too short, it may allow for increased strain during impulses

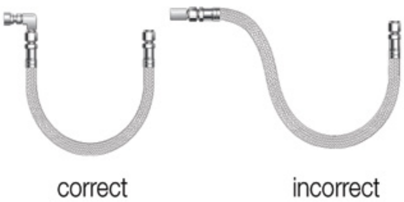

FIGURE 6. Not using elbows and adapters when necessary can also result in premature failure due to placing undue strain on the hose

plant maintenance, a change in system parameters could change the amount of strain a hose is under, thereby altering the replacement schedule (Figure 7).

Analyze your data

Collecting detailed information will only get you so far. It is important to look at this historical data and determine whether current inspection and replacement frequencies are sufficient. Some could be shortened, while others may need to be lengthened. On occasion, engineers should perform destructive tests on replaced hoses to see if they were replaced appropriately, as that may influence replacement schedule adjustments.

If a pattern emerges of a hose needing frequent replacement, it may be time to investigate alternative designs that could lengthen the replacement interval. Cost-benefit analyses of new hose types will allow you to make the right decision about whether a new hose construction should be considered.

Be prepared with spares

Another advantage to having a thorough understanding of hose replacement intervals is that spares can be ordered well before they must be replaced. For some hose categories, it even makes sense to have spares readily available on-site in case unexpected replacements are necessary. For example, plants should consider keeping the following types of hoses on hand.

Hoses for critical safety or process applications. It is imperative to keep readily available spares in inventory to correct any applications that present critical safety hazards or severe downtime potential.

Hoses that are likely to fail. When a hose's operating environment presents a high likelihood of premature failure, extra hoses should be on hand to accommodate frequent replacements. For example, hoses that kink, move in two planes, or experience vibration will likely fail earlier than others. However, as a best practice, it may make sense to find a more suitable hose for the application or adjust the system completely to remove the hose strain.

Hoses for special applications. Finally, keep spares of any hoses that are difficult to source due to special materials, lengths, end connections, and other variables. For example, if a special-order hose has a three-week lead time, it is imperative to inventory two spares for good measure.

Establishing an effective preventive maintenance plan does not happen by accident. Investing time in regular inspections and record keeping is essential and could improve a plant's profitability and safety records. Once the plan is operational, hoses will need to be replaced less often, and those hoses that still require high maintenance will be on hand just in case. Plant managers will be able to observe the effects of a well-considered preventive maintenance plan and observe a return on the investment of time and energy spent creating it. For help, they can work with hose suppliers capable of putting plants on the path to complete preventive maintenance plans. ■

Edited by Mary Page Bailey

FIGURE 7. Once hose replacement intervals are established, it is still critical to continue periodic hose inspections to ensure the intervals remain correct over time

All images courtesy of Swagelok

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Further reading

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Predictive Maintenance Basics

Enabled by modern digitalization tools, predictive maintenance strategies have distinct advantages over traditional approaches and preventive maintenance protocols

Namit Tripathi
Senior process engineer

The era of visual-inspection-only maintenance routines with an employee checking boxes off on a clipboard could soon become a relic thanks to predictive maintenance. In today's highly automated manufacturing environment, data collected from sensors can be analyzed to detect any maintenance issues that need to be addressed. Furthermore, those digital clues can also be harnessed to create predictive maintenance routines to help mitigate problems before they arise. Whether these issues occur in process equipment, pipelines or in other circumstances, information can be relayed to a software program to monitor for problematic conditions before costly downtime results. When scheduled on a regular, routine basis, predictive maintenance can help extend the life expectancy of physical assets, an important factor to consider when making an investment in current sensor technologies. This article describes predictive maintenance and outlines the benefits of using it for modern processes.

Predictive maintenance defined

Predictive maintenance (PdM) is a proactive technique that uses data collected in real time through an array of sensors (even drones, in some cases), historical performance data and advanced analytics. Those data are then analyzed by PdM software tools that use algorithms to forecast asset failure with a high degree of reliability unmatched by visual inspections alone. Cutting-edge technologies like artificial intelligence (AI) and machine learning (ML) are now employed more for PdM routines. The industrial internet of things (IIoT) allows data from critical operations to be transmitted remotely as well, alerting key personnel to detect failing assets in real time. This means that maintenance work can be scheduled ahead of an asset failure (a leaking pipeline or a seized pumping station, for example) on a routine basis to minimize costly downtime. The initial data collected can be used to train ML models to teach these algorithms how to make predictions or perform tasks. It is important to ensure those algorithms are programmed to avoid collecting information or noise that is not related to the task at hand, a condition that may impair the PdM methodology.

The type of data collected for PdM might include temperature or pressure variations (compared to an acceptable range or baseline number), flowrates, motor speeds (by monitoring the variable-frequency drive controller), or other metrics critical to a specific operation. PdM differs from preventive maintenance (PvM) — where routine maintenance occurs at predetermined intervals whether or not it is needed. PvM is often based on past experiences and timeframes, but that may not be a reliable predictor of future issues. The drawback is that it also may lead to unnecessary downtime.

Shifting from PvM to PdM

There are some issues to consider when making the shift from PvM to PdM. These include upfront costs associated with the hardware needed for monitoring systems (such as the sensors, for example), advanced analytical software programs to customize, employee hours to install new technology, and the hiring and training of employees required to analyze and then formulate a PdM plan. As with any major capital project, it is vital to factor the return on investment (ROI) into the equation. The direct benefits of using PdM are fairly straightforward. One indirect benefit is that a timeframe for PdM scheduled on a certain day or time slot can be relayed to customers, who can plan accordingly around that pause in operations. Performing those tasks on an emergency basis can be more costly (for example, extra shipping costs from expedited shipping of replacement parts, extra labor costs for repairs made outside of normal

IN BRIEF

FIGURE 1. Predictive maintenance can help extend the life expectancy of physical assets, reduce downtime, improve productivity and increase profitability

business hours). Switching from PvM to PdM helps organizations avoid the surprises that eat away at profit margins or result in penalties for failing to meet contracted deadlines.

Scada for data collection

A supervisory control and data acquisition system (Scada) involves a network of hardware and software systems that allows for real-time monitoring, supervision and control of machines and facilities. Sensors, programmable logic controllers (PLCs) and remote terminal unit (RTU) microcomputers collect the data. Human-machine interfaces (HMIs) display the critical data that enable operators to control key functions. Operators are provided with a deep dive into machine performance and production line efficiencies typically found in automated industrial operations. While traditional production-monitoring data are often siloed, Scada ties systems together to provide a more comprehensive data-acquisition tool and enable an enhanced "big picture" snapshot across the entire industrial automated process.

The end result is fewer unplanned setbacks, with scarcer unforeseen and unplanned shutdowns, such as emergency outages. The supply-chain issues that were evident over the past few years mean that keeping physical assets in operation is more critical than ever, especially with demand ramping up as a result of worldwide shortages of parts and finished products and the pent-up consumer appetite for goods post-COVID. This also keeps end users from looking elsewhere for other suppliers.

Maintenance strategies

PdM can morph into something more like PvM once there is a history developed over time through data analysis. This is a leap forward from run-to-failure (RTF) maintenance, which involves taking corrective actions after a piece of equipment fails. Because prior planning for maintaining equipment is not necessary, RTF remains feasible for non-critical assets that will not impact productivity and it can still be employed for cost savings. Conversely, the hardware and software installed for PdM are geared towards assets that are deemed critical to operations and must be kept up and running at all times, at least in theory. RTF is based on the concept that operational assets remain constant and in ideal condition, which often is not the case, as there can be unexpected failures and additional replacement costs with these assets. Without employing PdM strategies, the lifespan of physical assets may also be shortened. This can also impact capital expenditures.

Data-driven approaches to maintenance have emerged in recent years to eclipse model-based disciplines where degradation is based on prior knowledge — the recorded history of when failures have occurred. Once a model is built, it must be optimized manually on a regular basis to predict future maintenance more accurately, whereas AI can automatically and continuously optimize the data collected to establish those timelines.

Past history, however, may not accurately predict future breakdowns as equipment ages. Data analytics using algorithms fueled by AI and ML make PdM possible. Data screening is a first step, ensuring that only the information collected essential to the PdM process is used to make decisions. Some of the data produced may not really be an indicator of future problems. Statistical analysis (a monitoring approach without an actual machine inspection) shows when components are going "off-spec," indicating that a closer look is needed. That analysis leads to the prognostics approach — an engineering discipline that predicts when a system or component will no longer perform its intended function.

Making the move to PdM

As with any major investment, it is essential that buy-in for a move to PdM starts with the executive managers in the "C-suite." PdM needs to be viewed as a "must-have," rather than as a "nice-to-have," technology, so that it is accordingly incorporated into capital budget expenditures. It is also important to ascertain what others in the industry are doing. Are they investing in the hardware and software technologies and the human capital needed to make such a shift? Do competitors have less downtime or fewer pipeline or compressor failures, for example? Do preventive or model-based maintenance routines in place no longer provide enough protection against unforeseen downtime? As more suppliers of these technologies enter the marketplace, economies of scale could reduce those upfront investment costs. Identifying the components that should be upgraded to use AI for PdM, and where it may not be needed at the present time, is a step that should involve both upper management and other employees who can provide valuable insight as to where time and money are being wasted on unexpected maintenance.

Predictive analytics is helping companies in the energy sector using sensor technology gain new insights from the gleaned data, which help streamline decision-making timelines,

FIGURE 2. Predictive analytics, fueled by technologies such as artificial intelligence and machine learning, help companies gain new insights from the gleaned data, streamline decision-making timelines, and keep automated processes running smoothly

keep automated processes running smoothly and ultimately improve the customer experience (Figure 2). With the help of customized software packages, the identification of failing physical assets and better forecasts on the remaining life of that machinery is helping to minimize downtime. In the oil-and-gas industry, where unplanned idle assets due to plant problems can be very costly, a production facility shut down for repairs may take several days or even longer to come back online, if the undetected issue is severe enough. Downtime is not an option in the energy sector.

Condition monitoring uses an array of sensors that may employ vibration analysis, infrared thermography, ultrasonic testing and oil analysis to look for anomalies in the petroleum refinery or oil transport process. In the oil-and-gas sector, virtual rig monitoring that transmits information via IIoT means data can be gathered and transmitted elsewhere remotely without an employee being present onsite at a windswept offshore or desert drilling/pumping station. Detecting oil, natural gas or other chemical pipeline leaks more quickly can also help avoid costly fines for environmental regulation violations. Currently, however, many plants constructed decades ago continue to use visual maintenance where PdM technologies have not been installed or retrofitted, at least to an extent that produces maximum benefits.

It is also important to watch for improper data selection — a lack of coordination when employees from different departments are involved with data analysis, as well as poor modeling and inadequate training when launching PdM. Using the same personnel to collect the same data from the same location every time, known as repeatability, increases the confidence level in what datasets are being aggregated. Failing to keep up with the constant evolution of technology (the latest in sensors and software, for example) can lead to a competitive disadvantage, which is why it is essential to maintain and update the model guiding PdM routines as required, based on the latest data.

Looking ahead

There are numerous benefits that result from the implementation of PdM routines, including avoiding costly downtime, extending the life of equipment, and forecasting with more accuracy when a vital component may need to be replaced or upgraded. PdM provides a more holistic view of the physical assets that must be kept operational at all times. Including AI to collect data to monitor for issues using PdM routines can mean fewer "fires" to put out on a regular basis. Despite the possibility of significant upfront investment, especially for older facilities, less downtime means more profitability and the optimization of operations. Companies that take advantage of modern PdM can create a positive competitive edge. ■

Edited by Scott Jenkins

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Breaking New Ground: AI's Role in Biomanufacturing

Advanced technologies employing artificial intelligence (AI) and deep-learning models can reshape product inspection and quality control in bioprocesses, but users must understand both the capabilities and limitations of such digital platforms for optimal implementation

Riccardo Butta
Stevanato Group

Artificial intelligence (AI) has revolutionized the pharmaceutical industry, permeating every aspect from drug discovery to drug manufacturing. With its ability to analyze vast amounts of data, AI has become an invaluable tool in enabling the biopharmaceutical industry to bring safer and more reliable drugs to the market. Notable applications of AI in biomanufacturing, such as deep learning models and digital twin technology, can be implemented in visual inspection processes — all of which can provide drugmakers and biomanufacturers with increased productivity and improved efficiency (Figure 1). While these technologies are redefining the standards of drug development and manufacturing, they also come with drawbacks that drug manufacturers must overcome to reap the ultimate benefits of adopting these cutting-edge technologies.

The evolution of visual inspection

While manual inspection continues to be the gold standard for detecting defects across the drug manufacturing lifecycle, this process is time-consuming and labor-intensive. The market continues to demand a higher volume output. To address these limitations, drug manufacturers turned to automated inspection systems that incorporated advanced vision software and machine learning algorithms. The implementation of visual inspection equipment has significantly impacted the quality-control (QC) process for drug manufacturers, because it is essential in ensuring drug and container quality before the product gets distributed to the patient. These systems can efficiently inspect containers, detect defects, reduce false rejects, and ensure product integrity with high accuracy, significantly increasing manufacturing capacity.

By automating the inspection process, pharmaceutical manufacturers can improve productivity, reduce errors and enhance overall product quality. These systems can swiftly analyze images and identify even the tiniest defects or imperfections that may not be easily detectable by the human eye. By doing so, they provide a level of precision that surpasses manual inspection, ensuring that no potential issues are overlooked during the production process.

Manual inspection remains the regulatory standard today. However, the industry is seeing a pattern of increasing automation, using traditional rule-based algorithms and applying deep-learning models, as AI continues to permeate the industry. Every automated inspection system is challenged against manual inspection to prove efficacy, and this will also be the benchmark to be reached and surpassed by automation. The use of AI-powered vision equipment not only can enhance the efficiency of defect detection, but also reliability, allowing for a more precise analysis of inspection data. Moving forward, we foresee human inspection and AI continuing to work together, leveraging real-time data to improve production knowledge.

Deep learning for inspection

Deep learning has emerged as a powerful tool within the biomanufacturing industry, offering substantial benefits in terms of quality control and inspection performance. Particularly, when applied to visual inspection, deep-learning algorithms can significantly enhance accuracy and efficiency throughout the biomanufacturing lifecycle. By leveraging extensive training on large datasets, deep-learning models can detect subtle defects and anomalies (Figure 2).

This not only improves the overall product quality but also reduces the number of false rejects and reduces the need for manual re-inspection of "grey" items that do not meet quality standards. From manufacturing data, it can be seen that false rejects can be reduced tenfold, to less than 1%, and the detection rate can also be improved because of deep learning, yielding up to 99.9% accuracy. As a

FIGURE 1. Optical inspection is one of the major applications where AI and deep-learning technologies are frequently being applied in biomanufacturing processes

result, deep learning helps streamline the inspection process, saving both time and resources, and leading to a reduction in the total cost of ownership (TCO) for manufacturers. These robust systems can adapt to variations within production without the need to constantly adjust the inspection recipe, ensuring consistent performance and eliminating the costs associated with frequent modifications.

Being such a nascent technology, the main roadblock with deep-learning technology is the scarcity of defect examples to "train" the technology, especially with new products that have just entered production. This has sparked discussions within the industry around how to effectively validate the learning process and identify an effective way forward that pharmaceutical companies can adopt. Neural networks, which lie at the core of the deep learning process, possess the ability to continuously learn and adapt. However, this adaptability can make them seem like proverbial "black boxes," making it challenging to ensure that they abide by the predefined acceptable levels of performance. To address this concern, the practice of "freezing" the neural network is being widely considered as the preferred method of validation. By freezing the network at certain points during its learning, researchers and developers can evaluate its performance and check that it respects the identified appropriate levels of operation.

With its ability to enhance quality, increase inspection performance, and reduce operational expenses, deep learning has the potential to provide significant benefits to the pharmaceutical industry.

Digital twins

Further to the enhancements that visual inspection technology and deep-learning algorithms provide, digital twin technology offers yet another transformative approach in the field of biomanufacturing. By creating a virtual replica of real-world assembly processes, a digital twin enables risk prediction, minimizes errors and reduces delivery time.

Digital twin technology also applies real-time data to replicate complex supply chain processes, enabling drug manufacturers to identify potential weak spots and plan contingencies even before they occur. By leveraging machine learning and AI, the digital twin can analyze historical data patterns, compare them with real-time data, and predict the likelihood of future issues. As a result, maintenance teams can move from traditional, time-based maintenance schedules to condition-based strategies, intervening precisely when needed. Predictive maintenance minimizes downtime, prevents costly breakdowns, extends the lifespan of assets and optimizes maintenance costs by focusing efforts on critical areas. This approach not only enhances operational efficiency, but also boosts overall productivity and ensures a more reliable and sustainable operation of complex systems.

While digital twin technology can be extremely beneficial, the associated maintenance requires consistent money, time and effort from drug manufacturers. If a digital twin is not maintained properly, the effort to create the digital twin is voided, because it is no longer an exact replica of the process. For example, many errors across the biomanufacturing lifecycle are a result of outdated data, which can cause major delays as drug manufacturers need to spend time identifying the inaccurate data. To combat this, drug manufacturers can work with a partner that facilitates the implementation of infrastructure that collects, monitors and interprets data to ensure processes are running smoothly.

Overall, the implementation of digital twin technology in biomanufacturing holds the potential to significantly improve quality, increase operational efficiency and mitigate production issues.

Unleashing the power of AI

The integration of visual inspection technology, deep learning and digital twin technology has significantly enhanced accuracy and performance in biomanufacturing. Visual

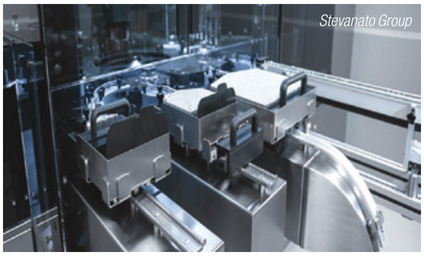

FIGURE 2. Deep-learning models are being implemented in quality-control schemes to quickly detect product defects and learn about manufacturing patterns

inspection technology enables the detection of even subtle defects, ensuring product integrity and safety. Deep-learning algorithms, when trained on extensive datasets, bring unparalleled precision and efficiency to quality control processes, reducing false rejects and minimizing manual re-inspections. Additionally, digital twin technology offers a virtual replica of the manufacturing process, facilitating predictive analysis, risk mitigation and resource optimization.

The combination of these technologies can lead to improved accuracy, increased productivity and streamlined operations in biomanufacturing, ultimately enhancing the quality and reliability of biopharmaceutical products. As these technologies continue to evolve and be integrated into processes, we can expect even greater advancements and innovations in the field, further solidifying their critical role in shaping the future of biopharmaceutical production. The companies that are best able to leverage these new capabilities will emerge as the victors, as AI continues to develop and shape the world we know. ■

Edited by Mary Page Bailey

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Preventing Dust Explosions with Flow Analysis

Dust collection systems are often designed using simple rules of thumb that may not be sufficient for proper operation. Flow analysis can ensure that the systems meet requirements

Ben Keiser
Applied Flow Technology (AFT)

The presence of dust is one of the many potential causes for explosions and fires at process plants. Dust collection systems can provide a significant level of explosion prevention, and they can also help maintain a safe working environment and reliable equipment operation.

Despite their status as critical components in a plant's overall safety infrastructure, dust collection system designs are often based on simplified rules of thumb, rather than being rigorously designed like other process units and systems in a plant. Using basic rules of thumb to guide designs can be problematic because designers assume that the rules of thumb will necessarily lead to a properly functional system. Flow analysis of dust control systems finds that this is often not the case. Dust collection systems that are "thrown together" without well-thought-out designs can introduce problems and the system may not work properly. In addition, new pieces of equipment get added to a process over time as production expands, and the dust collection system quickly becomes increasingly complicated. This leads to uncertainty regarding its functionality.

To reduce the risk of dust explosions and ensure that a dust collection system is meeting the requirements of the process, it is imperative to go a step further than rule-of-thumb designs and perform a system-level flow analysis. Accurate system-level flow analysis of dust collection systems is critical for explosion prevention in process plant operations. This article discusses considerations for flow analyses of dust collection systems, including the use of flow analysis to aid design for normal operation, as well as various operating scenarios when different components and flow paths are online at different times, and whenever additional branch paths are added into an existing system.

Potential dust hazards

There are five critical conditions that when met, can lead to a disastrous explosion event, such as the one that occurred at the Imperial Sugar Refinery in Georgia in February 2008 that killed 14 people and injured 38 others [*1*]. In addition to the three components needed for all combustion — fuel (in this case a combustible dust), oxidant and ignition source — dust explosions also require the dust to be dispersed in the atmosphere and confined.

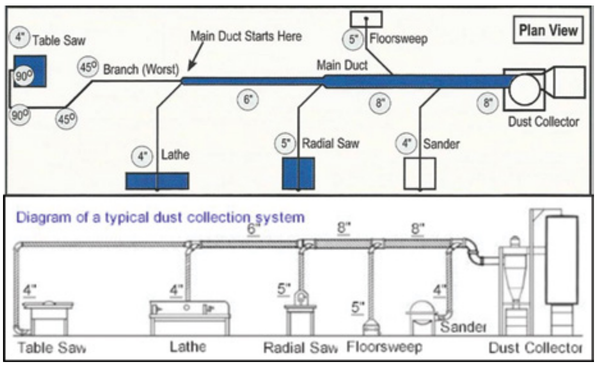

FIGURE 1. The diagram shows an example of a simple dust collection system with multiple pieces of equipment after layout and duct sizing has been determined

Dust is just one of the many fuel sources that can cause explosions and it is difficult to know which types of dust can explode, and under what conditions, and which ones will not. Therefore, whenever dust is present, a dust hazards analysis (DHA) is performed to determine the dust characteristics and assess the potential for explosion. With information from the DHA, plant designers and operators can determine methods of prevention and mitigation of dust explosions.

Design considerations

The primary function of a dust collection system is to provide points of entry into the ducting network where dust can be collected and then transported into a primary dust collector. The dust collection system is basically a large vacuum, so high velocities and flows are needed to transport the dust through the ducting network.

When dust collection systems are not working as they should, dust may start to accumulate within the ducting. If moisture is present, then dust can begin to stick to walls and fittings. This is just one of many examples of how a dust collection system may fail — continued analysis can help avoid this. The following are some of the main areas that must be considered for designing a dust collection system.

Flow velocities. If velocities are too low, then dust may settle and increase system pressure drop, which leads to higher energy costs, because blowers must overcome higher levels of resistance. Even worse is potentially plugging up the ducting. Excessively high velocities can also be an issue. High velocities can cause the dust to erode ducting and other network components. Also, dust flowing at too high a velocity may hit features like sharp turn elbows or branch line connections, which can potentially cause an accumulation of dust at those points. Another issue is that if dust is moist or sticky, it might smear along the wall, also leading to potential ducting erosion and accumulation.

The velocity in a certain duct

Type of dust		Velocity in branches	Velocity in main
Metalworking Dust		4,500 ft/min	4,000 ft/min
Woodworking Dust		4,000 ft/min	3,500 ft/min
Other Light Dust		4,000 ft/min	3,500 ft/min
ft^3/min requirements for diameter at specified velocity			
Diameter	**3,500 ft/min**	**4,000 ft/min**	**4,500 ft/min**
3 in.	170	195	220
4 in.	300	350	390
5 in.	475	550	610
6 in.	700	785	880
7 in.	950	1,100	1,200
8 in.	1,200	1,400	1,570
9 in.	1,550	1,800	1,990
10 in.	1,900	2,200	2,450
12 in.	2,800	3,175	3,600
14 in.	3,800	4,300	4,800

FIGURE 2. Example dust types have different velocity requirements and equipment flow requirements for various duct sizes at specified velocities

branch line may be adequate for proper transport. However, when it ties into another duct line, the combined flows may lead to excessive velocities. Combined flows and associated velocities are just as important to pay attention to as individual branch line velocities. Basic, rudimentary designs based on simplified rules-of-thumb likely will not allow designs to arrive at the correct flow velocities for a dust collection system.

Compressible flow. A major aspect of a dust collection system that is often overlooked is the fact that it is a compressible flow system. Most often, dust collection systems are assumed to be incompressible, and this leads to uncertainties when real gas effects are not dealt with correctly. Various rules of thumb exist that some will apply for when to treat a compressible system as incompressible and often these assumptions and rules of thumb fall short.

Due to the nature of compressibility, the flow inside the system will tend to accelerate. This can lead to excessive velocities and pressure drops and would not be determined and dealt with properly if constant velocities under incompressible flow assumptions are employed. Also, temperature change and heat transfer play an important role in compressible flow of gas piping and ducting systems. Compression heating through blowers will increase temperatures and it is important to monitor that the resulting temperatures do not reach unsafe levels.

Dust buildup. It is critical to ensure that dust does not collect and build-up within the ducting system. If it does, this can cause a dust collection system to become a part of the problem instead of part of the solution. Accumulated dust inside the ducting network is an explosion or fire hazard. Another major concern is that the accumulation can cause an explosion or fire that may have been started and caused by some other means in the plant to quickly propagate an explosion or fire through the ducting system itself.

System-level flow analysis

Overall, ensuring flow velocities that are not too low or too high, and obtaining the proper system flow capacity is easily achieved through system-level flow analysis. Once the design has been proven functional through the flow analysis, other operating scenarios must be considered. This includes simulating when various branch lines are online or not, as well as the effect on system performance if excessive dust buildup is present, or when the dust collector and filters need to be changed, and when branch lines are added and removed. Dust collection systems often evolve significantly over time and a quality flow analysis can save time in rebalancing the system.

Before designing a dust collection system, one needs to know the location of the equipment producing dust to identify the location of the dust collection unit. Floor-to-joist measurements need to be determined so elevation data can be handled properly. Any obstructions interfering with the ducting (such as walls or other pieces of equipment) or direction changes need to be known.

Next, the ductwork layout can be established. The duct sizes are then determined during the design and calculation process based upon the rules of thumb and associated flow and velocity requirements. Figure 1

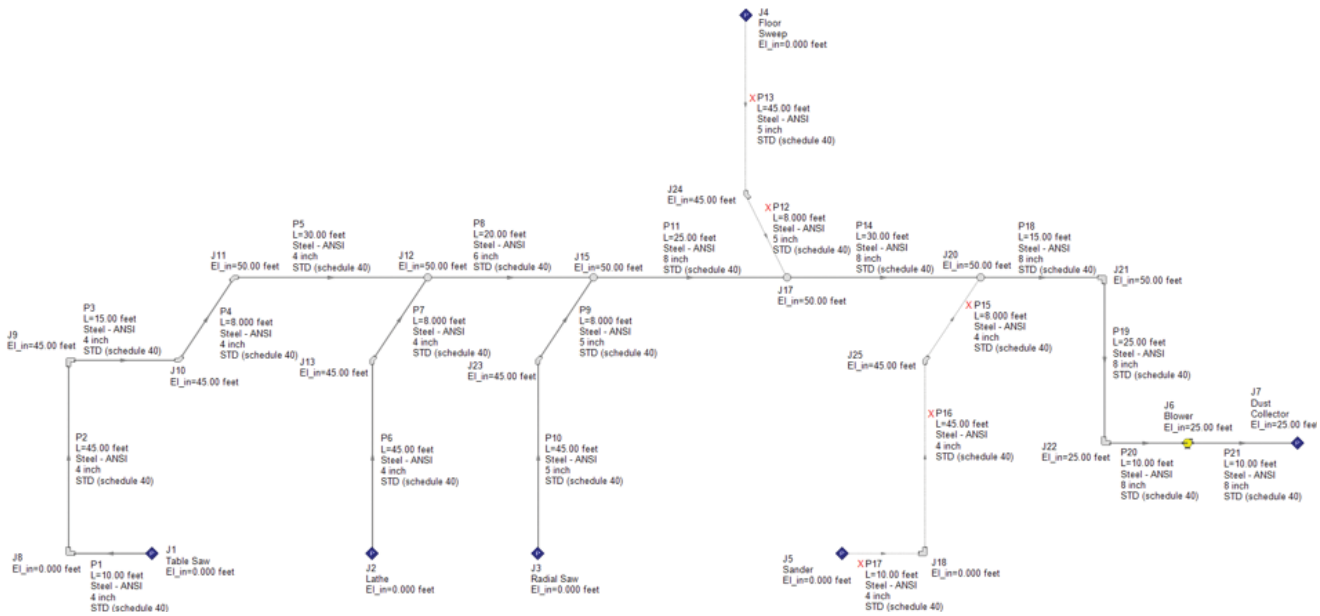

FIGURE 3. The diagram shows a system flow analysis model of the dust collection system example from Figure 1. Input is displayed for duct sizes, lengths, schedules, elevations and so on

is an example of a very simple dust collection system for a manufacturing facility. The system in Figure 1 is what the dust collection system might look like after the layout and duct sizing has been determined.

The basics of dust-collection system design start with the duct velocity requirements for transporting dust of different types. Velocities typically range between 3,500 and 4,500 ft^3/min. Based upon the specific velocities needed for the type of dust being dealt with, the ductwork can be sized for the branch lines from the equipment to the main duct headers depending on the flow requirements of the equipment. Figure 3 provides some examples of various velocity requirements for different kinds of dust and the flow requirements for different duct sizes at specific velocities.

Dust collection example

This manufacturing facility has a combination of "primary" and "secondary" pieces of equipment. Primary equipment usually includes major equipment units that are operating at the same time. This would typically start as a base-case scenario in a flow model to simulate the maximum flow requirements. In this system, the radial saw machine has a higher flow requirement than the table saw and lathe. The floor sweep and sander are secondary components that are considered to not be operating while the other three are during the main ducting header sizing process.

The design basis with only three "primary" pieces of equipment operating is another reason why flow analysis is critical. Consider the possibility that all five pieces of equipment are on at the same time? Will the ducting header still be the right size to handle the additional flow capacity to the dust collector? How much more pressure drop will there be with the higher velocities? Will main ducting velocities be too high that may cause problems discussed earlier?

These are all important questions that can only be answered with a detailed analysis. And this is only one other operating scenario where all pieces of equipment are operating. These same types of questions would apply for other cases that can include but are not limited to the addition of more branch lines for new pieces of equipment, the impact from dust buildup inside the ducting, and many other scenarios.

System resistance is usually also determined under rudimentary rules of thumb, which includes determining pressure drop based upon a certain length of ducting at different ducting sizes and velocities. Minor losses can either be dealt with by determining the losses in terms of inches of water, for example, or to convert the losses to equivalent lengths of piping. Once the design is finished, parts and equipment can be ordered and installed.

However, the question is: will this system work as designed? Unless users conduct a proper flow analysis, the assumption would be that it does work, and that can be potentially dangerous, if unchecked.

Software requirements

A flow model of the simple system in Figure 1 can be constructed relatively easily with flow-analysis software.

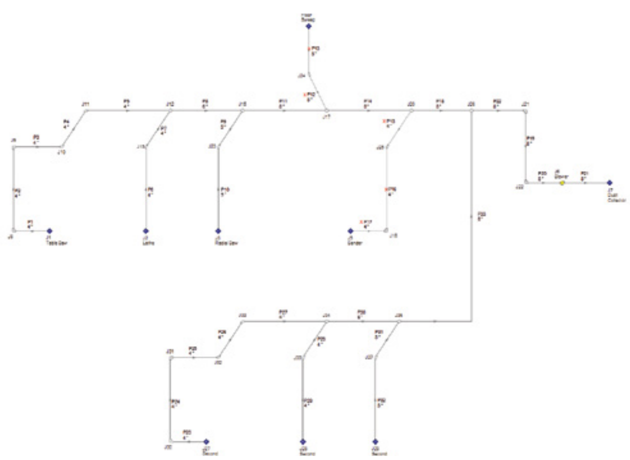

FIGURE 4. The example dust collection system now contains added equipment: a secondary table saw, lathe and radial saw

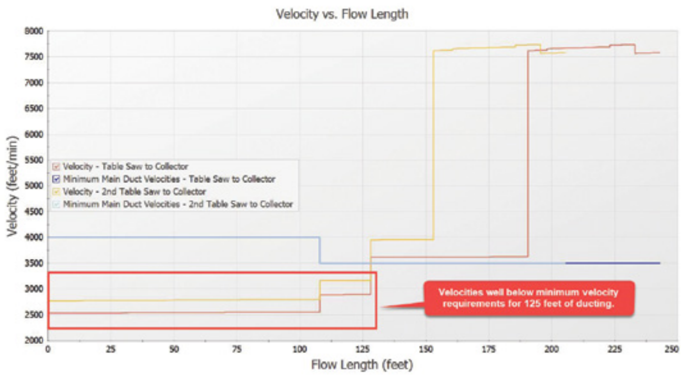

FIGURE 5. A plot of the velocity in the flow paths from each table saw to the dust collector from Figure 4. Velocities are well-below minimum velocities required in the first 125 ft (approximately) of ducting from each table saw

Make sure it is a flow-analysis software that properly handles the complex nature of compressible flow. Basic required input for the model would include duct sizes, lengths, elevation data, loss factors for minor losses and the flow requirements for the blower or fan. The system flow model might look something like that in Figure 3.

A quality flow-analysis software tool should allow users to easily display system model input information directly on top of the graphical model itself. This allows engineers to ensure the model is correct to achieve accurate results. It also helps others to be able to easily follow along with what is happening in the system if they are not intimately familiar with the design.

Another helpful feature that a quality flow-analysis software should have is the ability to alert the user when a design limitation is exceeded. The system model in Figure 3 has design requirements for minimum velocities and minimum flowrates in the various flow lines. Maximum velocities can be set up as well, to alert the user of possible erosion velocities. But for the sake of simplicity, this model only considers minimum velocities and flowrates. Erosion may take a long time and depends on the material and how long the system operates at erosional velocities. This may not always be as much of a concern in cases where velocities and flowrates are too low, where dust can begin to accumulate.

Identifying issues

After running a flow analysis for the scenario shown in the example in Figure 1 with only the table saw, lathe and radial saw operating, it was observed that the minimum required velocities and flowrates were not met in several areas. The velocities and flowrates were significantly lower than what they needed to be in the branch line with the table saw and the main ducting header between when the lathe branch line ties into the main header and where the radial saw branch line ties in. Therefore, we immediately can determine that the design that was established based upon rudimentary rules-of-thumb does not get the job done.

If this design was not checked with a system flow analysis, then dust collection problems may have started to occur and lead to a potentially terrible explosion incident that we all want to avoid. This analysis was only for one scenario. Other scenarios, such as when all pieces of equipment are operating, resulted in all the primary pieces of equipment and their branch lines not being able to meet the required velocities, as well as the main header line up to the point where the sander ties in. Again, this is another clear example of how the rules of thumb governing the dust-collection-system design will fail to produce a properly operating system.

Figure 4 provides an example of how systems quickly evolve and expand as new pieces of equipment and branch lines are added into existing systems. Expansions of dust collection systems are rarely ever analyzed, and similar to the way the initial design (based upon simple rules of thumb) does not work, the flow analysis model shows that the dust collection for the expanded network shown in Figure 4 will not work either.

The two most remote pieces of equipment to the dust collector are the two table saws (upper table saw and lower second table saw). Reviewing how various system parameters change over a flow path gives great insight into how the system is performing and where you might have an issue. Figure 5 is an example of the velocity profile plotted from both table saws to the dust collector. At least half of the ductwork in both paths from each table saw is not able to operate at a sufficient velocity for properly carrying the dust particles. Cross-plotting system parameters with their minimum or maximum values allows one to easily see where design requirements are violated.

Overall, dust collection systems are a very important piece of the strategy for prevention and protection against process plant explosions and fires. Simple rules-of-thumb approaches to the design of dust collection systems are likely to fall short. Therefore, it is critical to perform a system-level analysis to determine design feasibility, as well as how to start modifying design and potentially the operation to meet the appropriate requirements. Flow-analysis software makes it easy to effectively analyze systems for their function and effectiveness. Ideally, software will be employed that can not only analyze design, but can also help with design by automatically determining proper duct sizes that will meet requirements. ■

Edited by Scott Jenkins

Reference

1. Chemical Safety and Hazard Investigation Board (CSB), www.csb.gov/imperial-sugar-company-dust-explosion-and-fire/. 2008.

Editor's note: All diagrams courtesy of AFT

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Economic Indicators

2021 2022 2023

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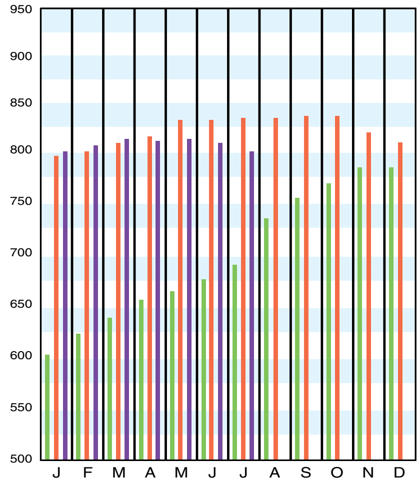


CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957–59 = 100)	July '23 Prelim.	June '23 Final	Jul. '22 Final
CE Index	798.3	803.3	829.8
Equipment	1,004.5	1,013.1	1,054.5
Heat exchangers & tanks	824.4	835.5	891.0
Process machinery	1,026.7	1,033.9	1,073.9
Pipe, valves & fittings	1,348.0	1,366.2	1,480.2
Process instruments	561.9	563.1	558.8
Pumps & compressors	1,459.5	1443.1	1,304.4
Electrical equipment	802.3	799.0	770.0
Structural supports & misc.	1,129.9	1,142.6	1,199.5
Construction labor	369.2	364.4	357.1
Buildings	812.6	816.8	834.2
Engineering & supervision	313.7	313.9	312.0

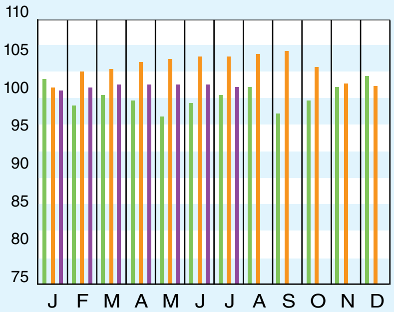
Annual Index:
2015 = 556.8
2016 = 541.7
2017 = 567.5
2018 = 603.1
2019 = 607.5
2020 = 596.2
2021 = 708.8
2022 = 816.0

Starting in April 2007, several data series for labor and compressors were converted to accommodate series IDs discontinued by the U.S. Bureau of Labor Statistics (BLS). Starting in March 2018, the data series for chemical industry special machinery was replaced because the series was discontinued by BLS (see *Chem. Eng.*, April 2018, p. 76–77.)

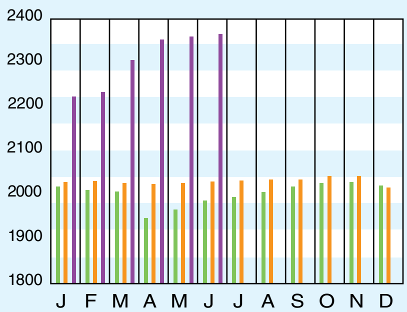
CURRENT BUSINESS INDICATORS

CURRENT BUSINESS INDICATORS	LATEST	PREVIOUS		YEAR AGO
CPI output index (2017 = 100)	Jul. '23 = 99.1	Jun. '23 = 99.3	May '23 = 99.3	Jul. '22 = 100.9
CPI value of output, $ billions	Jun. '23 = 2,312.5	May '23 = 2,311.0	Apr. '23 = 2,344.4	Jun. '22 = 2,611.7
CPI operating rate, %	Jul. '23 = 79.0	Jun. '23 = 79.2	May '23 = 79.2	Jul. '22 = 81.3
Producer prices, industrial chemicals (1982 = 100)	Jul. '23 = 313.7	Jun. '23 = 320.4	May '23 = 323.3	Jul. '22 = 379.7
Industrial Production in Manufacturing (2017 =100)*	Jul. '23 = 99.5	Jun. '23 = 99.0	May '23 = 99.6	Jul. '22 = 100.2
Hourly earnings index, chemical & allied products (1992 = 100)	Jun. '23 = 223.0	May '23 = 219.0	Apr. '23 = 219.5	Jun. '22 = 200.9
Productivity index, chemicals & allied products (1992 = 100)	Jul. '23 = 92.7	Jun. '23 = 91.6	May '23 = 90.9	Jul. '22 = 90.5

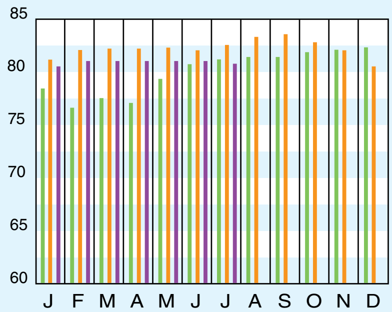
CPI OUTPUT INDEX (2017 = 100)†



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2012 to 2017
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

CURRENT TRENDS

The preliminary value for the *CE* Plant Cost Index (CEPCI; top) for July 2023 (most recent available) fell compared to the previous month's value, the second straight monthly decline. To arrive at the decline in the overall CEPCI for July, decreases in the Equipment, Buildings and Engineering & Supervision subindices offset an increase in the Construction labor subindex. The current CEPCI value now sits at 3.8% lower than the corresponding value from July 2022. Meanwhile, the Current Business Indicators (middle) show decreases in the CPI output index and the CPI operating rate for July 2023, and a slight increase in the CPI value of output for June 2023.